Mr Read Supply Div.
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LABORATORY PRACTICE

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Mr Bishop R.117
Mr. Glynn R.117

RESEARCH · CONTROL · TEACHING

VOL. 8 No. 4 Published Monthly APRIL 1959

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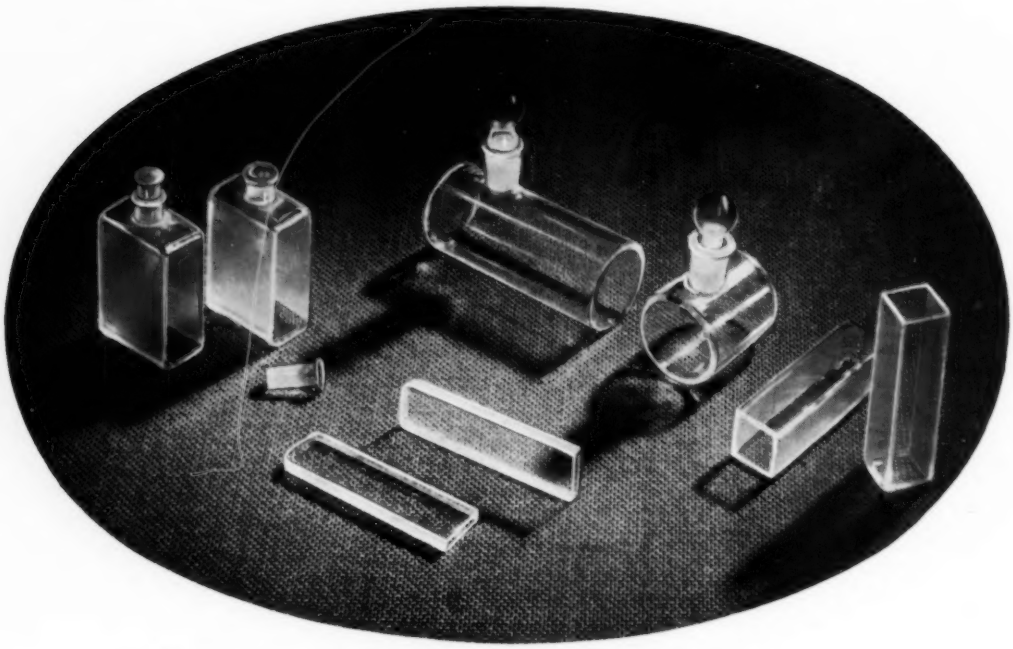

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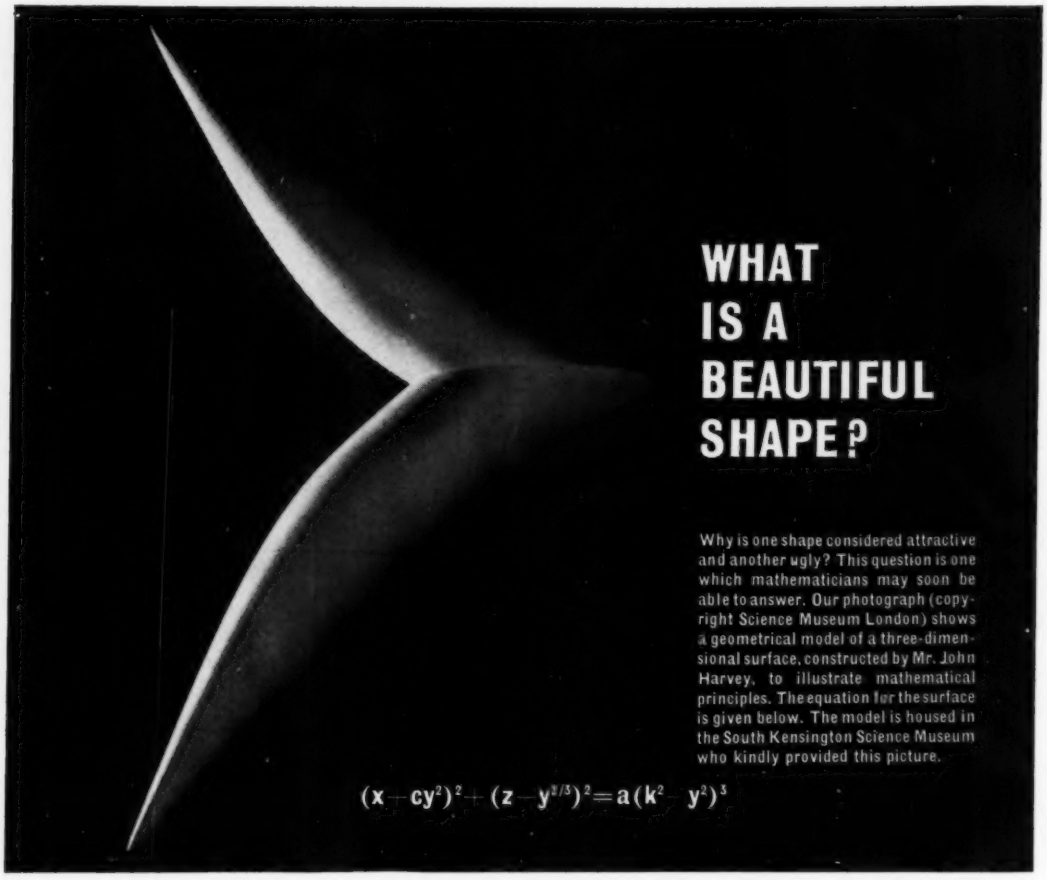

WHAT IS A BEAUTIFUL SHAPE?

Why is one shape considered attractive and another ugly? This question is one which mathematicians may soon be able to answer. Our photograph (copyright Science Museum London) shows a geometrical model of a three-dimensional surface, constructed by Mr. John Harvey, to illustrate mathematical principles. The equation for the surface is given below. The model is housed in the South Kensington Science Museum who kindly provided this picture.

$$(x - cy^2)^2 + (z - y^{3/5})^2 = a(k^2 - y^2)^3$$

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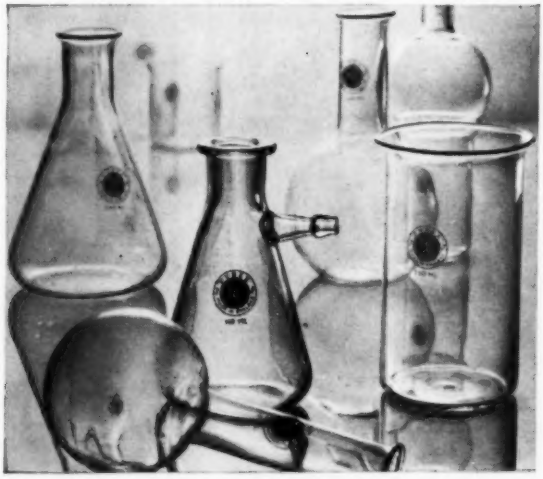

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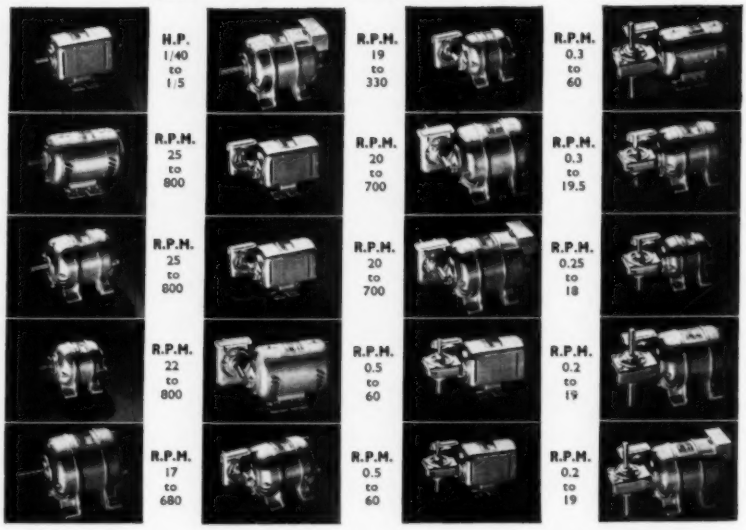

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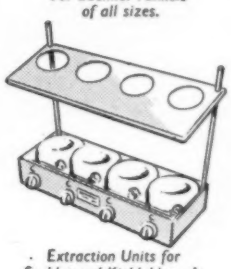

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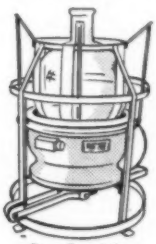

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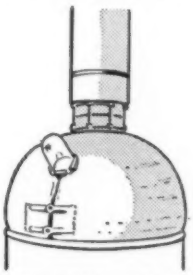

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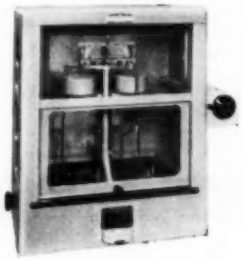

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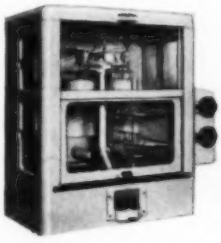

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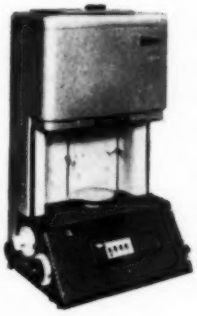

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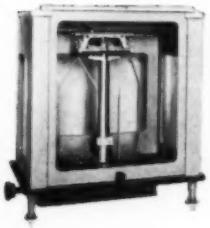

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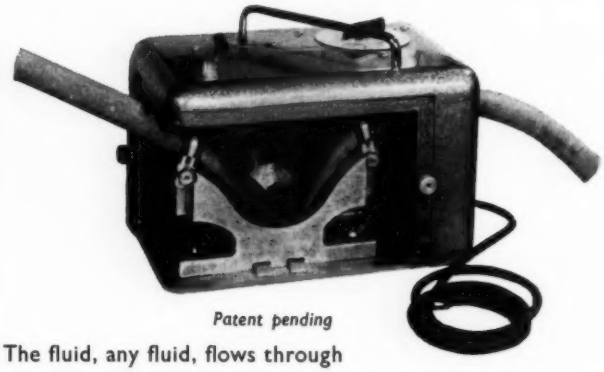

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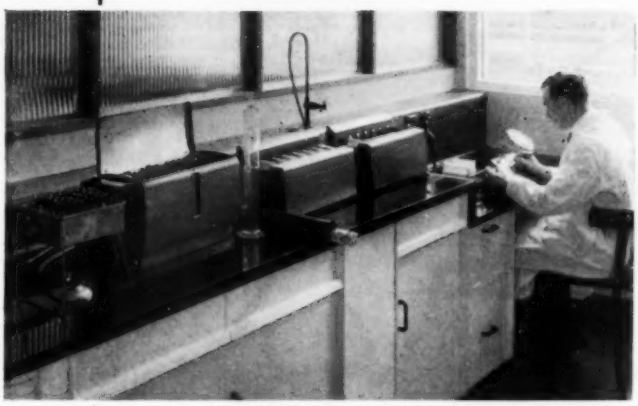

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7.5	1.82	2.58	3.16	3.65	4.47	5.48	6.32	8.17
10	1.58	2.24	2.74	3.16	3.88	4.74	5.48	7.07
15	1.29	1.83	2.24	2.58	3.16	3.87	4.47	5.78
25	1.00	1.41	1.73	2.00	2.45	3.00	3.46	4.47
50	.707	1.00	1.23	1.41	1.73	2.12	2.45	3.16
75	.578	.818	1.00	1.15	1.41	1.73	2.00	2.58
100	.500	.707	.866	1.00	1.23	1.50	1.73	2.23
150	.408	.575	.707	.818	1.00	1.22	1.41	1.82
200	.354	.500	.612	.707	.866	1.06	1.22	1.58
350	.268	.378	.463	.535	.655	.803	.926	1.19
500	.224	.316	.388	.447	.548	.671	.775	1.00
1,000	.158	.224	.274	.316	.388	.474	.548	0.708
1,500	.129	.183	.224	.258	.316	.387	.447	.578
2,500	.100	.141	.173	.200	.245	.300	.346	.448
5,000	—	.100	.123	.141	.173	.213	.245	.315
7,500	—	.081	.100	.115	.141	.173	.200	.258
10,000	—	—	—	.110	.125	—	.173	.224
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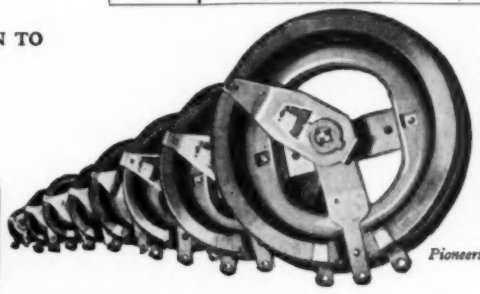

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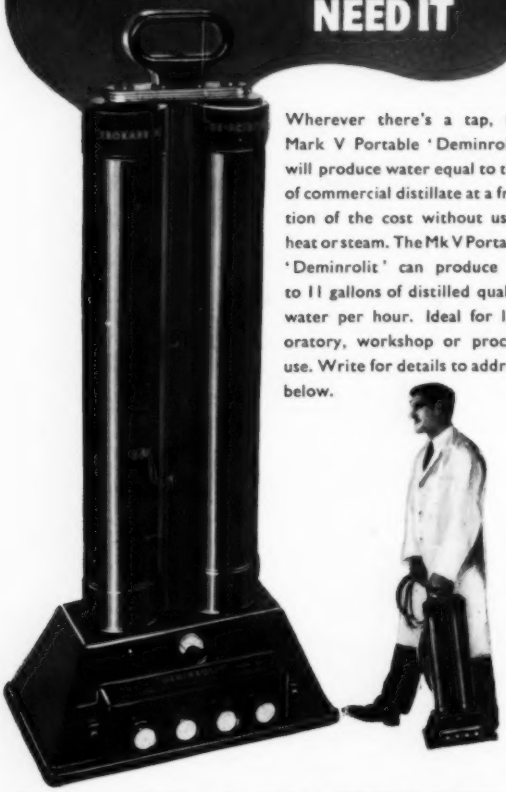

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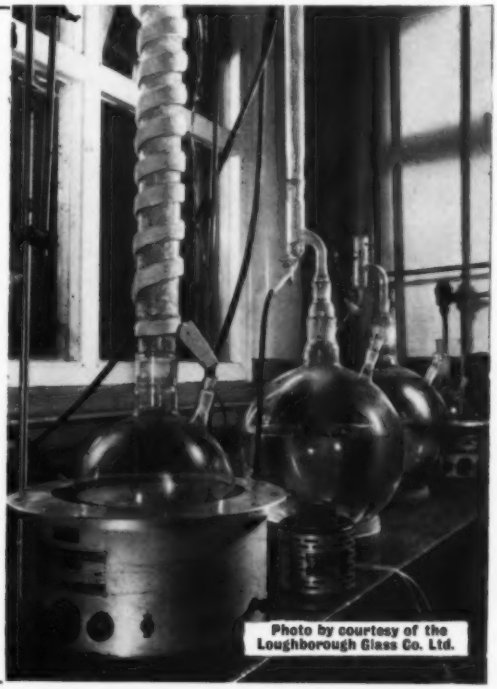

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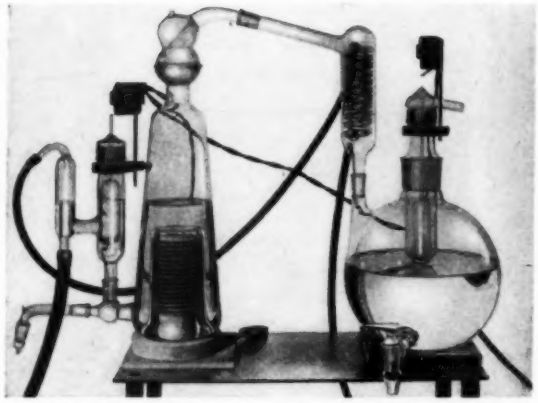

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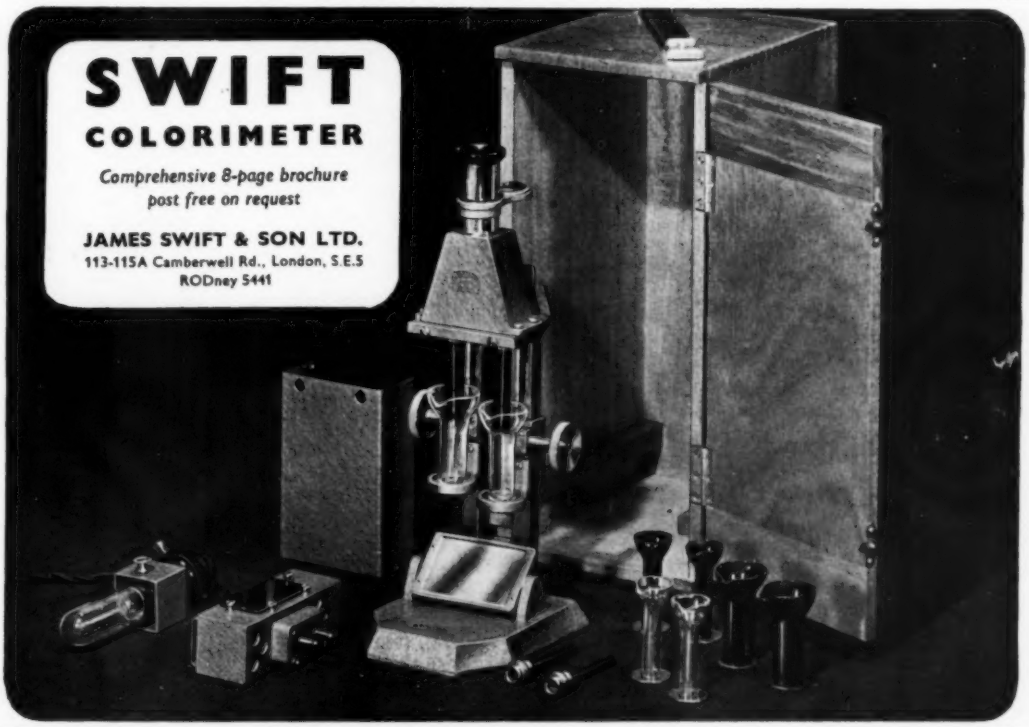

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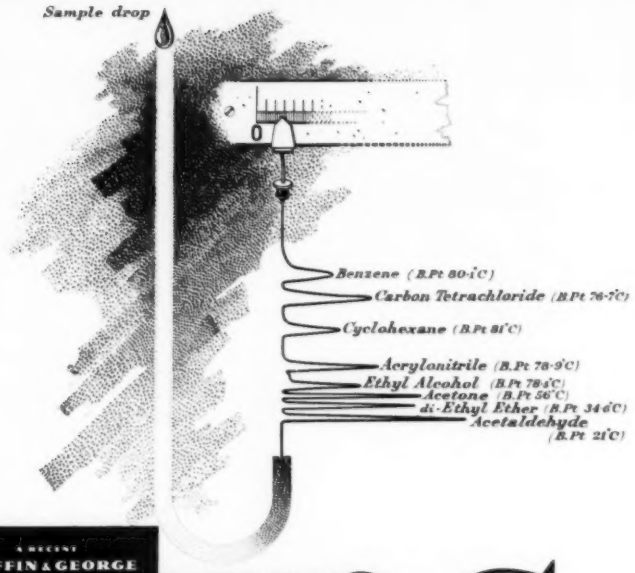

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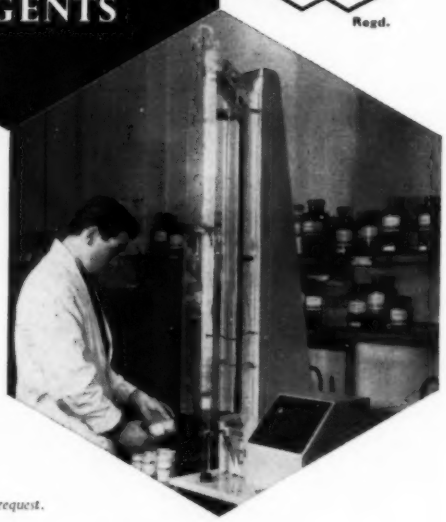

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EDITORIAL

Statistics in Research

TODAY no scientist can work only in his own discipline. A problem is rarely confined to one narrow branch of science or to one type of technique. A chemist may have to use the resources of physics, electronics or metallurgy on one occasion, and on another those of botany or microbiology. These ancillary approaches may vary, but for all scientists and especially for research workers there are two aspects that they must never forget—the ability to plan their research upon a sound statistical basis and to write a clear, concise account of their findings afterwards. The research worker who sets out on any piece of research involving multiple factors without statistical guidance is like a man who hazards his health without first consulting his doctor. The time to seek advice is before embarking on the work. How often has a research worker in the past completed his work only to be told afterwards by the statistician that the plan was faulty? Fortunately liaison is much better today; scientists can appreciate the value of statisticians, and statisticians can make themselves understood by scientists. This co-operation is particularly necessary in biological research, where variation in behaviour exceeds anything in the physical sciences.

Variety as the spice of life may be more enthusiastically welcomed by biologists in their leisure pursuits than in their professional researches. For here, variation necessarily introduces the research worker to the activities of those who, though sometimes described in less publishable ways, are generally termed statisticians. Time was when they could be particularly disconcerting; a sympathetic headshake accompanied by some formidable esotericism—'too few degrees of freedom apart from biassed estimates I'm afraid'—could easily induce a diminished sense of the importance of the statistical contribution and might (though only if repeatedly encountered) ultimately affect one's ideas on the egregious merits of one's own research.

Enlightened biologists soon learned to avoid such dispiriting comments by planning their experiments jointly with a statistician, not hoping to hoist him with his own petard, but genuinely aiming to improve the

efficiency of their researches. Others introduced statistical methods into their technical repertoires from textbook expositions.

With experience came the gradual realization that statistical methods cannot sufficiently be regarded as simply technical adjuncts or as processes for attaching editorially acceptable standard errors to the means of observations. Instead it became apparent to many that statistical rationale, having developed especially to deal with variation, really embodies for biological research the modern equivalent of the classical scientific method. This aspect is well illustrated by the major statistical content of E. Bright Wilson's recent book 'An Introduction to Scientific Research'.

Those of us who are engrossed in our own specializations may reasonably be allowed to feel that our own directors should, perhaps *inter alia*, make it their responsibility to concern themselves with discussions on general aspects of research. The increasing permeation of quantitative techniques, however, makes the statistical aspects a subject of individual relevance, and we shall do well to examine for ourselves whether our ideas on the appositeness of statistics have kept pace with the rapid developments in this discipline. Enterprising biologists will, for example, already be noting the versatility of those highly topical ACE'S, DEUCE's, etc., so that even before the time the king computer is everywhere available, problems will be found extending beyond the programmed analyses of statistically designed experiments. Such problems will inevitably lead mathematicians to a deeper knowledge of the appropriate biological processes and conversely.

There is already considerable scope for team work of this enlightened character bridging gaps arising from academic trainings in separate subjects. In particular, the naïve and sometimes apprehensive attitude that statistical methods should be confined to numerical analyses will evanesce, both disciplines converging, with only a difference in emphasis on the two syllables of the joint study—biometry.

In this issue we are publishing an article which gives a very broad, philosophic survey of the subject. This will serve as an introduction to a series of articles which follow and which will deal with specific terms and methods in statistics. Although written in general terms these articles are intended to be of special usefulness to research workers in the biological field.

Society for Analytical Chemistry

The eighty-fifth Annual General Meeting of the Society was held on Friday, March 6, 1959, in The Meeting Room of the Royal Society, Burlington House, London, W.1., with the President, Dr. J. H. Hamence, M.Sc., F.R.I.C., in the Chair. The Financial Statement and the Report of the Council for the past year were submitted and approved, and the Auditors were appointed.

The following Officers and Members of Council were elected for the forthcoming year: *President:* R. C. Chirnside; *Past Presidents serving on the Council:* J. H. Hamence, D. W. Kent-Jones, J. R. Nicholls, K. A. Williams; *Vice-Presidents:* D. C. Garratt, Magnus A. Pyke, J. G. Sherratt; *Honorary Treasurer:* A. J. Amos; *Honorary Secretary:* R. E. Stuckey; *Honorary Assistant Secretaries:* L. Brealey (Programmes Secretary), S. A. Price. *Other Members of Council:* N. L. Allport, H. E. Brookes, R. A. Chalmers, W. T. Elwell, C. H. R. Gentry, J. Haslam, E. I. Johnson, G. W. C. Milner, R. F. Milton, F. C. J. Poulton, T. S. West and C. Whalley. *Ex-Officio Members:* J. R. Edisbury (Chairman of the North of England Section), A. N. Harrow (Chairman of the Scottish Section), S. Dixon (Chairman of the Western Section), S. H. Jenkins (Chairman of the Midlands Section), F. Holmes (Chairman of the Microchemistry Group), R. A. C. Isbell (Chairman of the Physical Methods Group) and J. I. M. Jones (Chairman of the Biological Methods Group).

Analysis of Intact Samples

The subject of the 65th Ordinary Meeting of the Physical Methods Group of the Society for Analytical Chemistry was 'The Analysis of Intact Samples' and the following papers were presented and discussed:

'*The Use of Beta and Gamma Absorption Methods in the Analysis of Intact Samples*', *by J. F. Cameron, B.Sc.* (*U.K.A.E.A., Harwell*).—The predominant use of gamma-absorption techniques employs the Compton scattering process for determining density. It has the advantage that it provides a non-contact measurement which can be made continuously through the walls of containers such as pipes, or tanks and is used, for example, on petroleum products, ice cream, acids and slurries of cement, thoria, and uranium. The H-C mass ratio of hydrocarbons can be determined.

Photoelectric absorption of low energy photons is a rapidly varying function of atomic number and hence can be used as an indication of mean atomic number. The scope of the technique is severely restricted, firstly by the lack of radioactive isotopes emitting low energy photons and secondly by the absorption of this radiation in the container walls. The concentration of uranyl sulphate and uranium 'pulp' in aqueous solution and the sulphur and lead concentrations of hydrocarbons is thus determined.

Beta-absorption methods are used in gas analysis and smoke detection.

The accuracy of such measurements is usually limited by the statistical variations in the detector output due to the random rate of emission of radiation from the radioactive source. Choice of detector and source energy, theoretical accuracy effect of container wall, thickness, etc, are considered.

'*The Use of Radioactive Isotopes in Simple X-ray Fluorescent Analysis*', *by C. E. Mellish, B.A., D.Phil.* (*U.K.A.E.A., Harwell*).—For many applications of X-ray fluorescence spectroscopy the full performance of the conventional spectrometer is not required. In these applications it is possible to substitute a small radioactive source (~1 millicurie) for the X-ray tube, provided that the crystal spectrometer is also dispensed with and resolution of the fluorescent X-rays produced is performed in a proportion or scintillation counter. Results were given of the application of this simple system to such problems as the measurement of metal plate thickness and of solution strengths. The suitability of different isotope sources for different applications was discussed.

'*Analysis by Nuclear Magnetic Resonance Techniques*', *by J. D. Ferrett, M.A., D.Phil.* (*U.K.A.E.A., Harwell*).—The phenomenon of nuclear magnetic resonance, in which responses can be obtained from nuclei that have spin, offers a technique for the analysis of intact samples of solids, liquids and gases. Equipment demands are rigorous, e.g. magnets with highly uniformed fields and electronic circuits with low noise levels. The information obtained can be both qualitative and quantitative and can be used as an aid to the elucidation of the structure of complex organic molecules.

LABORATORY EQUIPMENT TEST REPORT—No. 37

ADIABATIC BOMB CALORIMETER

Manufacturers: A. Gallenkamp & Co. Ltd., Sun Street, London, E.C.2

Price: Ranging from £185 to £255 according to accessories required.

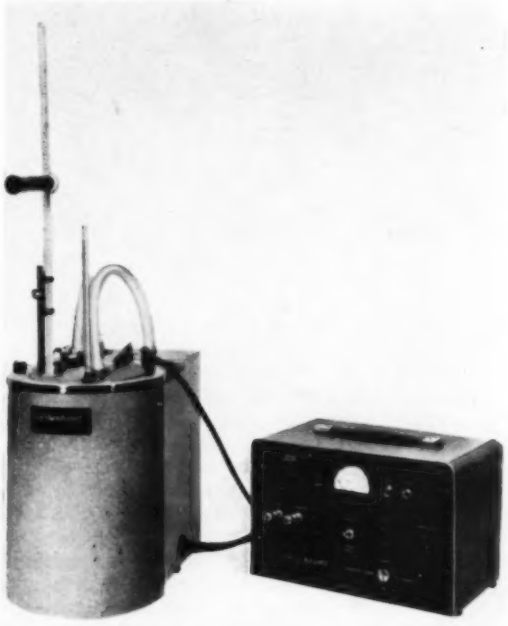
A BOMB calorimeter apparatus used for determining the calorific value of combustible materials consists essentially of (*a*) a high pressure bomb, (*b*) a calorimeter vessel and (*c*) a water jacket which provided with a suitable lid completely surrounds the calorimeter. The apparatus is commonly used in fuel laboratories, its construction and use for determining the calorific value of coal and coke being prescribed in British Standard Specification 1016 Part 5, 1957.

The principle of determining calorific values is that an accurately weighed quantity of fuel is combusted in the bomb which is charged with oxygen at 25-30 atmospheres pressure. The heat of combustion is transferred from the bomb to a standard quantity of water surrounding the bomb in a calorimeter vessel. Increase in temperature sustained by the water is accurately measured by means of a fixed range thermometer calibrated to 0·01 °C. and read as near as possible to 0·001 °C. Increase of temperature experienced by the calorimeter system on combustion of the fuel is dependent upon the heat of combustion of the fuel, the heat capacity of the calorimeter system and the loss or gain of heat by the system due to external conditions. The effective heat capacity of the system is determined experimentally by combusting in the apparatus a fuel of known heat value (usually benzoic acid). Results of such determinations, expressed in calories per unit temperature rise experienced by the system, is a constant for any given system. Any change in the system such as the use of a different thermometer will necessitate the determination of a new constant. The influence of external conditions upon the increase of temperature of the calorimeter system is corrected for by the application of a cooling correction. The method most commonly used is that due to Regnault and Pfaundler (1866); other methods are proposed by Dickinson (1955) and Moser (1936). Accuracy of the cooling correction is dependent upon the provision of adequate thermal insulation to the calorimeter system so as to reduce its magnitude to a minimum.

Thermal insulation from external sources is provided by the water jacket. The major developments in bomb calorimeter design during recent years have been concerned with providing more efficient water jackets.

In the static and isothermal bomb calorimeters the aim is to provide a constant temperature enclosure for the calorimeter. The static model relies solely upon its water capacity to provide a thermal barrier while the isothermal model is provided with thermostatic control of the water jacket temperature. The water jacket of the adiabatic bomb calorimeter is provided with instantaneous heaters which are controlled by a sensitive electrical system maintaining the jacket water temperature the same as the calorimeter during the whole period of operation. Thus theoretically there should be no heat exchange between the calorimeter and the water jacket, thereby eliminating the necessity to apply a cooling correction.

The assessment of the cooling correction involves the recording of accurate temperature observations at precise intervals of time (usually one minute, 30 or 15 seconds for greater accuracy). These observations commence from a time when the rate of change of temperature in the calorimeter system becomes constant, continuing for at least five minutes before firing the fuel charge, and ending not less than five minutes after a constant rate of change of temperature has been resumed. Thus there is a period of approximately 20 minutes during which the operator is involved in making tedious observations and laborious calculations. By careful pre-adjustment of the initial calorimeter water temperature or the jacket water temperature when



The adiabatic bomb calorimeter.

using the static or isothermal apparatus, the operator can reduce the time for the attainment of constant rate of temperature change and also reduce the magnitude and error of the cooling correction. With the static jacket at the mercy of ambient conditions much time can be expended in suitable pre-adjustment of temperature. In addition, due to seasonal variations of ambient temperature, determinations of calorific value have to be carried out over different ranges during the course of a year. These require several fixed range thermometers, which increases the cost of accessories and requires the determination of different heat capacities appropriate to each thermometer resulting in the expenditure of additional time and labour. The use of isothermal conditions implies a standard temperature range and the pre-adjustment of the calorimeter temperature to a standard figure facilitated by storing the bomb calorimeter and supply of water for the calorimeter at the requisite temperature. Again, operating over a standard temperature range only one thermometer is required. The employment of adiabatic concepts eliminates the necessity for an applied cooling correction, provides rapid automatic adjustment of temperature equilibrium and operates over a fixed temperature range.

The adiabatic bomb calorimeter apparatus consists of:

(*a*) The bomb, the body and cap of which are machined from forged stainless steel bar complying with B.S.1506-845 Grade B. The cap is secured by a locking ring machined from rolled aluminium bronze bar. The joint between the body and cap is made by a toroidal sealing ring which enables a gas tight seal to be effected by hand tightening only. The oxygen filling point is fitted with a Schrader type valve and the union between the bomb and the filling tube is sealed with a toroidal sealing ring which is also designed for tightening by hand. Two Inconel electrodes are fitted to the cap, one has a ring support for flanged crucibles and is electrically connected to the cap, the other is insulated by a plastics bush.

(*b*) The calorimeter vessel made of stainless steel polished on the outside. The overall dimensions are approximately $5\frac{1}{2}$ in. diameter $\times$ $8\frac{1}{4}$ in. high, and 2 litres of water just cover the bomb. Three metal pegs are fixed inside to support the bomb a sufficient distance from the bottom to allow free circulation of water around the bomb, and a wire lifting handle facilitates assembly into the water jacket. It is also fitted with a stainless steel shaft which has two stirring rotors designed to operate at about 400 rpm. A cover is provided to minimize evaporation losses.

(*c*) The water jacket and cover are $8\frac{1}{2}$ in. diameter $\times$ 13 in. high overall and are constructed of stainless steel, polished inside and stove enamelled grey duotone outside. An electrically driven centrifugal pump mounted at the rear circulates water through the jacket and cover, the latter is hinged and has flexible water connections. The jacket has an overflow tube and an internal coil through which cooling water is passed to adjust the jacket temperature between tests. Two electrode heaters built into the jacket provide instantaneous heating which permits accurate following of the calorimeter vessel temperature during a test. Temperature changes are detected by a thermistor in the water jacket which is matched with a second thermistor placed in the calorimeter vessel. The thermistors are connected to the control unit by coaxial cables and form arms of a Wheatstone bridge the amplified output from which actuates the heaters. The cover has tubulures for the calorimeter stirrer shaft, thermometer and thermistor and for the bomb firing lead. It is fitted with a thermometer support rod.

The calorimeter assembly is located inside the jacket by a spacer which serves the dual purpose of minimizing thermal contact between the two vessels and providing an electrical contact through which the current passes. The stirrer is driven by the pump motor through rubber belts and an intermediate layshaft for speed reduction.

(*d*) The control unit is housed in a steel case 8 in. high and 12 in. wide $\times$ 8 in. deep finished to match the calorimeter. It comprises a Wheatstone bridge circuit, amplifier, heater relay, bomb firing system and associated switches, fuses and indicator lamps.

Two arms of the bridge circuit consist of high stability resistors and a rheostat, the other two arms being formed by the thermistors in the water jacket and the calorimeter vessel. Out of balance signals from the bridge are amplified by a two stage resistance-capacity coupled amplifier and fed to a phase-sensitive detector which closes a relay in the electrode heater circuit when the jacket temperature falls below that of the calorimeter vessel. The firing circuit is fed from an earthed 8V winding on the mains transformer, rated at 64 V.A. for 10 seconds duration. The circuit includes a biased-off switch and a 5A fuse. The current in either the firing circuit or the heaters can be read from an ammeter on the panel by manipulation of a change-over switch.

To operate the apparatus the bomb and calorimeter vessel are charged and assembled in the usual manner. It is necessary that the bomb, the calorimeter vessel and its lid shall be assembled in the appropriate position in order that the holes in the calorimeter vessel lid shall coincide with the corresponding tubulures in the jacket lid. This is facilitated by the provision of a visual lining up aid. The lid of the jacket is closed down, the stirrer driving belt, calorimeter thermometer and firing lead placed in position, and the control unit switched on. Before placing the thermistors in position they are balanced by placing them together in a beaker of water and adjusting the rheostat setting until the heaters are just brought into circuit as indicated by the ammeter. The thermistors are now placed in position and water run through the jacket cooler until the temperature is

just below that of the calorimeter. This is indicated by the ammeter showing that the heaters are brought into circuit and can be checked by comparison of calorimeter and jacket water temperatures. The flow of water through the cooling coil is now reduced and time allowed for thermal equilibrium to be attained between calorimeter and water jacket. The first calorimeter temperature is now recorded and the fuel charge ignited by depressing the firing switch. A deflection of the ammeter and return to zero with the firing switch depressed indicates that the firing system has functioned. During the combustion of the fuel the ammeter shows that the heaters are rapidly brought in and out of circuit to keep the jacket temperature following closely with that of the calorimeter. Slowing down of deflections by the ammeter indicates the approach to equilibrium following combustion. When equilibrium is finally reached (normally an interval of seven to eight minutes) the second temperature can be recorded and the calorimetric determination is complete. As the final temperature remains constant due to adiabatic principles it can be recorded at any convenient time, within reason, after maximum temperature of the calorimeter system is reached.

The apparatus has been under test in a Power Station Laboratory for several weeks and has been found to justify the manufacturers' claims.

Repetitive determinations of effective heat capacity have given a range of results within 0·15 per cent of the mean value. This is well within maximum tolerance required by British Standard Specification which calls for a range within 0·30 per cent of the mean value.

Comparative determinations of calorific values have been carried out between the static apparatus in use and the adiabatic apparatus, using various samples of coal and fuel oil. Differences between results on each apparatus varied between 9 and 65 B.Th.U. These comparisons were made in the same and in different laboratories, the maximum difference of 65 B.Th.U. being found on a comparison made between a static apparatus in one laboratory and the adiabatic apparatus in another. The maximum tolerance allowed by British Standard Specification between laboratories is 120 B.Th.U. The results are therefore well within the maximum tolerance.

The above results indicate that provided due care and attention are paid to the setting up of the static apparatus its accuracy compares favourably with that of the adiabatic bomb calorimeter.

The advantages of the adiabatic apparatus over the static and isothermal apparatus are: (i) more rapid determinations, (ii) reduction in operator fatigue, the operator not being continuously tied to the apparatus, and (iii) the elimination of laborious cooling correction calculations. In order to obtain a further assessment of the above features a work study was made of the same operator carrying out a determination of the calorific value of a coal on each apparatus. The results of the study are summarized in Table I.

TABLE I

	Static Apparatus	*Adiabatic Apparatus*	*Saving*
Number of operations	36	14	22
Number of transportations	3	3	Nil
Number of inspections	25	8	17
Number of delays	3	2	1
Time of determination	39 min. 43 sec.	26 min. 35 sec.	13 min. 8 sec.

In the study the operator stood over the adiabatic bomb during the whole period of determination and the estimated time saved does not include the period when the operator could in fact have left the apparatus and proceeded with other work, as there is no necessity to maintain a continuous record of temperature change. An additional period of approximately 15 minutes can thus be added to the time saved as shown in Table I.

When the work load is heavy it is suggested that if a spare bomb and calorimeter vessel were available the bomb could be charged and the whole assembled ready for insertion into the jacket immediately a preceding calorimetric determination had been completed. Thus a rapid sequence of determinations would be possible.

The general construction of the apparatus shows a pleasant, neat and compact appearance. A reduction in overall height as compared with earlier models will be appreciated by the operator during assembly. The use of stainless steel construction of the calorimeter and water jacket is a considerable improvement compared with the more usual chromium plated materials. Thermistors are enclosed in robust cases and should withstand hard usage. The apparatus is capable of rapid and easy assembly. In particular the simple electrical connection to the bomb is appreciated which is made by passing the firing lead directly through the jacket and calorimeter lids to a single socket connection in the head of the bomb. Only one criticism can be levelled against the apparatus as tested, that is with reference to the thermometer clip which is considered to be too fragile allowing sideways movement of the thermometer.

The following recommendations are made for general improvement:

(*a*) The ring support for carrying crucibles should be made detachable and secured with a screw clamp to the bomb electrode. This would enable the use of the varying sized rings to accommodate the design of crucible most suited for the complete combustion of any type of fuel. Details of crucibles are given in published reports of studies made of the fundamental principles involved in the determination of calorific value by R. A. Mott and co-workers (1954-58).

(*b*) A valve release accessory should be provided to enable gases (remaining in the bomb after combustion of the fuel charge) to be exhausted through a suitable oxidizing solution. The determination of acid gases formed during combustion can then be proceeded with immediately the calorimetric determination is completed. Without such a facility a standing period must be allowed for acid mists to settle in the bomb before exhausting to atmosphere.

(*c*) The rheostat setting for balancing the thermistors has been found to be delicate. The provision of an arbitrary scale would be of advantage to indicate the position of the rotary switch, any accidental movement of the setting being readily rectified.

It may be observed that in having achieved a close approach to automation in bomb calorimetering one must be careful that operators do not take liberties in its use. For example, the final check of thermal equilibrium of the calorimeter is the observation of constant temperature, and it is recommended that more than one thermometer reading should be taken before and after firing the bomb with not less than minute intervals between them. The extra time expended is insignificant compared with the general saving of time obtained with the use of this apparatus. In addition the possibility of error due to misreading the thermometer will be reduced.

Conclusion

The design and construction of the apparatus are good. It is capable of giving results comparing favourably with the accuracy of static and isothermal models with a considerable saving of time and operator fatigue, and consequent reduction of possible experimental error.

MANUFACTURERS' NOTE: *The calorimeters are now being produced with an improved thermometer clip. They also have a scale for the initial balance control. Interchangeable ring supports for* 25 *mm. and* 38 *mm. diameter crucibles and an adjustable pressure relief valve are available.*

REFERENCES

British Standard 1016: Part 5: 1957. Methods for the Analysis and Testing of Coal and Coke.
Dickinson, H. C. (1915). Bull.U.S.Bur.Stand, **11**, 189.
Moser, H. (1936). Phys.Z., **37**, P529.
Mott, R. A. and Thomas, W. C. (1954). Fuel, **33**, 448-461.
Mott, R. A. and Barker, J. E. (1954). Ibid., 462-467.
Mott, R. A., Barker, J. E., and Thomas, W. C. (1955). Ibid., **34**, 283-302 and 303-316.
Mott, R. A. (1956). Ibid., **35**, 261-280.
Mott, R. A. and Moulson, I. (1956). Ibid., 476-491.
Mott, R. A. (1957). Ibid., **36**.
Mott, R. A. (1958). Ibid., **37**, 3-18.
Regnault and Pfaundler, L. (1866). Ann.Phys., LPZ 129, 102.

BOOK REVIEWS

British Instruments Directory and Buyers' Guide. London: United Science Press Ltd. 1959. £2. 2s. net. pp. 620.

In past years, two publications have served the instrument industry: *British Scientific Instruments* compiled and published by the Scientific Instrument Manufacturers' Association and the *Instrument Directory* compiled by the staff of *Instrument Practice* and published by United Trade Press Ltd. The value of having one common publication to serve the interests of the whole instrument industry was recognized by both concerns, and it was agreed to merge the two separate publications into one. *The British Instrument Directory and Buyers' Guide*, now published, is the result.

It comprises some ten sections.

Section 1.—Trade and other associations allied to the instrument industry.

Section 2.—List of British Standard specifications relevant to instrumentation.

Section 3.—Consultants, engineers and installers of instrumentation schemes.

Section 4.—Firms manufacturing prototypes or small batches of instruments.

Section 5.—Classified list of instruments and instrument components together with names of manufacturers.

Section 6.—A glossary of the instrument and component headings in Section 5 in French, German and Spanish. These are in alphabetical order in the relevant language with the equivalent English heading alongside.

Section 7.—Names and addresses of instrument and components manufacturers mentioned in Section 5 together with their foreign agents.

Section 8.—A list of selected trade names.

Following these eight editorial sections are two more. One has some 400 pages of what are officially termed Manufacturers' Announcements. These are aimed to present concise details of manufacturers' products and should provide a mine of information on these. They are *not* in the nature of advertisements which have a section to themselves.

Such is the bare outline of the contents. This, however, does not convey the value of the information. For example, the classified list of instruments and components in Section 5 has over 2,500 headings covering measuring and control instruments for the normal physical conditions such as temperature, flow, pressure, humidity, liquid level and so on; automatic control systems for machine tools; automatic and manual inspection instruments; general electronic instruments; automatic data processing systems (computers, etc.); electrical instruments; aeronautical instruments; meteorological instruments; surveying instruments; gauges for physical dimensions; instruments for physical and mechanical properties; optical instruments; texture measuring instruments; analytical instruments; weighing systems; nucleonic instruments.

The aim has been to present the wide range of British instrumentation to all those at home and abroad engaged in the field, and everyone so engaged should possess a copy.—J. T. MILLER.

MATHEMATICS AND BIOLOGICAL RESEARCH

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Introduction

Relations between the older sciences of biology and the comparatively modern discipline of statistics are continually developing as advances in statistical methods assist in the extension of existing knowledge and also expose further research problems in both sciences. The early attitude that statistics is an incubus to biological research was probably due in part to the fact that many statistical developments arrived too late to be incorporated into the training of the older and currently responsible generation of research workers, who may indeed have been attracted to biological studies by their comparative freedom from mathematics. Such attitudes are becoming exceptional and yet the frequency of discussions on statistics in research (examples—Yates, 1946; Hill, 1947; Cochran, 1949; de Beer *et al.*, 1950; Bailey, 1952; Finney, 1956) suggests that wider appreciation of the potentialities and limitations of mathematical and statistical methods is still desirable.

The Nature of Research

'Copying from one book is called cheating; copying from many books is called research' has been given as an inductive definition of research. Less pejorative definitions could be attempted showing that the term covers a wide range in the degree of creative activity and novelty in different disciplines. In mathematics, for example, a research result immediately achieves a universal, or at least terrestrial, validity while in agricultural development work, on the other hand, the repetition of an experiment carried out to confirm or deny the original findings under different circumstances, may still be admitted as research. The unhelpful distinction between 'pure' and 'applied' research should also be disposed of, for in general the primary distinction of pure or fundamental research seems to be simply that its prosecutors are unable to see or do not seek its *immediate* application. Yet in the history of science there are numerous instances of posterity harvesting benefits from once fundamental and apparently non-useful studies, such as those concerning the properties of $(a + b\sqrt{-1})$. In many cases closely similar techniques are used in both pure and applied research and, while it may be true that greater creative endeavour is often shown in research which is well ahead of its application, this is not necessarily so and much depends on the individual workers concerned.

The definitive feature of research is the creative process of working from the known to the unknown—remembering that the unknown is relative and may depend on place and time. And if the process is carried out with sufficient vigour we may generally describe research as a war on ignorance. From this it follows that the most efficient weapons are desirable and among these the powers of statistical techniques in biology are already widely appreciated. It will be shown, however, that to regard the functions of mathematics and statistics in biological research simply as techniques is to take an unprofitably limited view.

Particular divisions of research can be envisaged: experimentation, planned and unplanned, has been extensively discussed by Beveridge (1950); operational research has developed greatly since its wartime origins (examples—Blackett, 1948; Goodeve, 1948; Yates, 1949; Waddington, 1951) though the opinion sometimes expressed, that this activity must necessarily be characterized by a recommendation to executive action does not appear essential, its rigorous application could exclude numerous investigations on experimental techniques which can plainly be considered as examples of operational research. Finally we may note the beginnings of research into the strategy and efficiency of research itself (Yates, 1952; Grundy, Healy and Rees, 1956).

The Scientific Method in Classical Science

One important aim of scientific research may be regarded as a process of rationalizing phenomena, of reducing them to particularizations of general 'laws' and as a process of extending the field of valid application of such laws. The procedure is throughout pragmatic and theories carry in them the seeds of their own demise: predictions are made as to the behaviour and properties of the material world and as soon as observations appear which are inconsistent with the theories these are modified or replaced.

'To use another metaphor, the history of science may, as has been said, be full of beautiful theories slain by ugly little facts, but those theories did not die in vain if before their death they had subdued a vast number of jarring facts into a law-abiding populace.' (Andrade, 1956.)

Here a close relationship between the apparent validity of theories and the accuracy of existing experimental techniques may also be noted. As techniques improve, deviations previously undetected or accepted as experimental error, are revealed as consistent discrepancies—in simple cases curves are required where straight lines formerly sufficed and, as a classic example, accurate observations on the orbit of the planet Mercury led from Newton's theory of gravitation to the special theory of relativity.

The pervasive feature in the realization of the above

aims by practical research is the scientific method. This, with beginnings discernible in Galileo's experiments in the sixteenth century, c.f. Butterfield (1957), has now become an implicit attitude of mind in the modern scientist and, in its close association with applied mathematics, has directly engendered the extensive achievements of the physical sciences. The essentials of the classical scientific method are contained in the repetitive sequence: hypothesis—deduction—experimentation—deduction, wherein a particular hypothesis may be an intuitive distillation, consistent with and projective from what is already known in a given discipline or, more familiarly, may itself be a logical deduction from general theory. Deduction is, in fact, the complete characteristic of the method and the simple classical experiment is arranged so that a comparison between the observed outcome and those deduced as uniquely necessary consequences according as the hypothesis is assumed to be true or false, will permit its confirmation or negation. Galileo's apochryphal experiment on the landing times of weights dropped from the Pisa tower would have provided one early instance, the Michelson-Morley experiment another.

Contemporarily basic knowledge in science tends to become mainly embodied in 'laws' which relate in mathematical fomulae quantities, similar to Platonic ideas, abstracted from the physical world. Hypotheses have correspondingly been expressed so that experimentation could be aimed at the measurement of predicted effects deduced mathematically from the hypotheses. Hence the recurrent emphasis on the importance of mathematics in science. Thus, among the Greek mathematicians:

'. . . Pythagoras and his disciples, who saw in numbers the key to most problems and asserted, 'Things are numbers'. If we do not take this too literally, it marks an important stage in intellectual development, since it establishes the principle that a large mass of phenomena can be understood if we can discover mathematically the laws which govern them.' (Bowra, 1957).

In the Italian Renaissance: 'There is no certainty where none of the mathematical sciences can be employed or in the case of things which cannot be connected with mathematics.' (Leonardo da Vinci.)

And in the most vigorous days of classical physics: 'In physical science a first essential step (in the direction of learning any subject) is to find principles of numerical reckoning . . .' (Kelvin, 1891).

Conversely in the absence of the quantitative approach, Butterfield (1957) comments on the slower development of chemistry: 'The phlogiston theory—the theory that something was lost to a body in the process of burning—is a remarkable evidence that at this time* the results of weighing and measuring were not the decisive factors in the formation of chemical doctrine.' (Butterfield, 1957).

The introductory chapter in Thompson (1948) gives a further and erudite development of the theme represented by the above quotations.

*17th Century.

Biological Variation

The simplicity of the scientific method in the physical sciences follows from the fact that the *en masse* physical properties of matter are generally stable provided that observations are made in sets of circumstances which are closely similar, particularly in respect of locally controllable variables such as temperature, pressure and humidity. Experimental material in biology is, however, markedly more sensitive to environment and interesting speculation can be directed towards more fundamental reasons for this. We may note the generally greater homogeneity of physical material in terms of density and compare the complexities of integral units such as the molecule and cell. Again, interaction due to water omnipresent in both environment and living tissue may contribute to observed variation; the effective precision of *in vitro* biochemical experiments is, however, not always increased by analysing them on the conventional tissue dry weight basis. More expeditiously perhaps, we can place the difficulty at one remove and attribute much of the greater biological variation to the fact that repeated observations in this case necessarily include variation due to the continual processes of growth, reproduction and dissolution which, proceeding at different rates even in different parts of the same organism, induce faster structural changes than those occurring in inanimate materials. Relatedly, the objects of some experiments often involve the exacerbation of such biological processes when it is reasonable to expect the natural variation to be substantial relative to the investigated responses. Further, in many biological studies, the observational unit is a response of a single individual which, although possessing a recognizable unity, is nevertheless an assemblage in some respects similar to a factory, not readily paralleled in the investigations of physical science until comparatively recently. And finally, biological responses are in general greatly dependent on measurement techniques (or conversely, these are not yet sufficiently subtle), a factor which not only contributes to variability but also causes peculiar difficulties in attributing general validity to findings.

Given variability then as a permeating characteristic of biology and accepting that progress in a scientific discipline demands a quantitative treatment of its subject, the basic necessity for statistics in biological research immediately follows, for in fact modern statistics may be defined as the science of variability. Thus we may write:

statistics is to biology as applied mathematics is to physics.

The joint study from the first half of the proportionality is termed biometry which compares with mathematical physics on the right hand side, so that if the analogy continues we may expect some remarkable developments in quantitative biology. Here, however, it must be remembered that the number of mathematicians

attracted to biological research is small relative to the total 'volume' of such research and to the number of biological problems wherein sustained quantitative and theoretical investigations would be enlightening.

Classical Statistics in Biological Research

The first concept of number is an intuitive abstraction—for example, 'four' is the common attribute of (2 + 2) apples and of (3 + 1) mice—with which relatively few people experience any difficulty. Far more, however, do not achieve the second abstraction required for facility in applying the rules of arithmetic to the literal numbers of elementary algebra. And yet one further abstraction is required to begin the understanding of statistics in biological research. This is the concept of an infinite population or collective underlying a particular set of observations. The necessity to think in terms of parent frequency distributions, emphasized in the early statistical literature by Karl Pearson and R. A. Fisher, involves perhaps the most important intellectual step in quantitative biology. Once this essential faculty has been obtained, the potentialities of statistical methods as weapons in research, i.e. their heuristic powers, will themselves be clearly seen distinct from the purely technical manipulations of statistical analyses, on which, together with particular design details, the more attention appears to have been focused in elementary texts.

A first and obvious function of statistics in biology concerns the concentration of the information contained in large collections of data into a few derived quantities, themselves called 'statistics', which will characterize the original data sufficiently for the practical purposes in mind. From these statistics one would usefully expect an indication of whether the observations are distributed symmetrically or otherwise about some representative value such as the mean, and some measure of the dispersion of the individual observations provided by, for example, the standard deviation. For an empirical approach such statistics can, of course, be calculated from any set of observations, but it will generally be more useful, following Fisher (1946) to regard the problem as one of specifying some theoretical form for a distribution of possible values of which the set of actual observations can be taken as one random sample. The general specification will be embodied in a mathematical formula containing a number, preferably small, of constants or parameters. If the distributions corresponding to different parameters were plotted, some general features would be retained but particular differences would appear in, for example, the dispersions of the possible observations. The problem then is to obtain from the data, estimates of those parameters which will formulate a theoretical distribution most appropriate to the particular set of observations being examined. For some commonly occurring distributions guidance will be found in statistical texts on the selection from various alternatives of those estimates having optimum properties such as absence of bias and minimum variance.

The above is perhaps the simplest statistical treatment available for large bodies of data and even so it should not be applied uncritically without remembering, for example, that the estimates are not absolutes but are always qualified by the circumstances in which the original observations were obtained. With the development of small-sample theory, the most important contributions of statistics to biological research have probably arisen in connection with the controlled experiment wherein the inherent variability of biological material has necessitated differences in the principles of scientific method. This will now be considered in more detail.

The Scientific Method in Biology

The genesis of any investigation may be regarded broadly as the response to two questions:

(*a*) what are the objects of the investigation?

(*b*) how best can these objects be achieved?

One object may be simply the determination of an isolated quantity, such as the weight of an individual under defined circumstances, but the commonest experiments in biology are generally essentially comparative in nature. Even a comparative experiment, however, will be concerned with making estimates, in this case of differences, determined from observations on material incorporating differences in applied treatments or previous history. And in the specification of an experiment it is desirable to take account of the relative emphasis required between the related discriminatory and estimatory aspects. The latter have been emphasized by Yates (1946) for agricultural experiments where treatment responses are considered in an economic context. On the other hand in some investigations, of fundamental physiology or biochemistry for example, the immediate aim may be the elucidation of underlying processes requiring the detection of small quantities of substances involved in biochemical reactions. Here, sensitive experiments giving high if 'local' precision, supported by tests of significance, may be more informative. Regarding variation as 'noise' the estimatory experiment requires 'Hi-Fi' characteristics while the discriminatory experiment has analogies with radio communication equipment designed for a high signal/noise ratio over a more restricted frequency band. With both types of experiment the essential fact is that findings will only be capable of valid generalization to that biological material and those circumstances which have been effectively represented in the particular enquiry. It is also to be remembered that statistically controlled experiments are, by definition, artificial and involve local interference and restrictions on biological processes. Accordingly, results may reflect interactions due to the observational procedures which may have no counterpart in the natural behaviour of the experimental material.

With such general considerations in mind therefore we can pass to the detailed examination of the fundamental contributions of statistical discipline to that

scientific method characteristic of biological research. This may be formally exhibited as a cycle of:

hypothesis
plan and design
execution
analysis
interpretation

Previous experiments and knowledge will usually indicate the general objects of an experiment and although it has been suggested (Finney, 1956) that a statistician will not generally be responsible for initiating the research, the converse view (Bradford Hill, 1956) may find more adherents if the collaboration with experimental workers repeatedly advocated by statisticians increases. Because collaboration in defining the objects of an experiment or series of experiments may be even more productive for the development of the quantitative approach to research than collaboration at the planning stage, the issue is not trivial and will be further discussed in a later section. In any case, what is certainly required before planning proper can proceed is some formulation, coding—or even programming—of the objects of the investigation into hypotheses capable of quantitative examination against the background of natural variation.

Statistical considerations are pertinent to a number of aspects in the planning of experiments. First it is essential to ensure that it is the desired hypothesis and this alone which will be tested. Subtle confounding factors may be introduced by the experimental circumstances and the methods by which treatments are applied, particularly with the type of experiment carried out 'as far as possible under practical conditions of management'. The detection of such factors is not, of course, a purely statistical activity, but a general sensitivity towards biasses may be expected to assist in their removal especially from among the experimental techniques (see, e.g. Yates, 1935). Second comes the question of making an optimum allocation of the generally limited resources of time, experimental material, etc. to ensure that an experiment giving adequate precision to the principal observations is undertaken and here the statistician may be able to contribute with estimates of variation obtained from similar previous studies and with an appreciation of available design possibilities. Third at the planning stage, it is necessary to discuss the incorporation of the principles of experimental design and, in general, especially that of randomization, into the projected experimental procedures. Such ideal collaboration naturally confers collateral benefits—the statistician becomes further educated in the context and aims of the experiments, in practical details and their disturbance by design essentials and may even be able to anticipate statistical problems which will arise in future studies. Lastly, decisions which effectively determine the main pattern of the statistical analysis are taken during the planning discussions. The analysis and the extent to which findings may be safely generalized are determined in the specification of the postulated mathematical model, its attendant assumptions and its relevance to the biological circumstances, subjects of which statisticians have recently shown increased awareness (Tukey, 1954; Wilk and Kempthorne, 1955; Cox, 1958).

The extent to which biometricians participate in practical processes of experiments has generally been small and perhaps too small considering the converse exhortations for increased statistical awareness in biologists. When time permits and the techniques involved are suitable, biometricians might very usefully be encouraged to investigate practically some aspects, for example the sampling methods, and obtain results of value for subsequent experimentation.

The necessity to be aware of developments in techniques and principles may tend to make the analysis of results a primarily statistical function yet it will frequently be found that discussion with experimenters is required in reaching decisions as to what should be done in particular cases, for example when observations are incomplete.

Differences in the scientific method necessitated by the relatively large biological variation are emphasized when the findings of statistical analyses are interpreted and a gradual refocusing of attention on the issues involved can now be discerned in statistical literature. The essential process is now one of induction not deduction, a process of proceeding from the particular to the general. Discriminations between treatments are accompanied and qualified by probability statements and their correct assessment against the 'null hypothesis' that observed differences are simply particular chance effects necessitates careful thinking in terms of frequency distributions previously referred to. Statistical training is obviously valuable here since the logic of uncertain inference is closely connected with statistical methodology and its practical applications (Anscombe, 1948; Fisher, 1955; Pearson, 1955) and 'The basic problem of statistics is that of decision-making in the face of uncertainty'. (Girshick, 1953).

Nevertheless the interpretation of analyses cannot be regarded as exclusively statistical operations on mathematically expressed probabilities. Underlying even the problem of decision in uncertainty is the necessity to identify and specify the parent population or collective to which any inductions are to apply noted, for example, in Fisher (1955). More generally, this necessity involves a specification of the *relation* between the sample and the population, a question which rarely receives explicit consideration in reports of experiments where the scarcely qualified relation 'membership' is often tacitly assumed to be sufficient. On induction Russell (1948) remarks: 'I incline to think that valid inductions, and generally, inferences going beyond my personal past and present experience, always depend upon causation, sometimes supplemented by analogy.' This, together with Wiener's comment given later in this section, emphasizes the desirability of close collaboration at this stage. Further, significance levels, for example, are conventionally arbitrary and although in ideal circumstances they are decided before the

examination of the results, the difficulties of repeating costly experiments may emphasize the occasional admissibility of some deviation from rigour in this respect when supporting *a priori* information from the experimenter is available and distinct from wishful thinking. Questions on the utilization of such *a priori* information, weighted according to its content of knowledge or opinion, might repay more careful examination in terms of the possible losses ensuing from alternative decisions which are in the last analysis necessarily subjective, for example, Snedecor (1950). Discussions on the interpretation of results may also reveal that adventitious inflation of the variability, or some deviations from plan have occurred during the course of the experiment which necessitate some modifications to the formal analysis.

Similar considerations may apply when the objects of an experiment are mainly estimatory. Indeed it may be worth noting that when estimates are being examined in an economic context the observed effects are virtually being compared with those differences reckoned to be of importance in practical applications, comparisons which can be examined experimentally if controls representing basic practice are included. The interpretation of such estimates may perhaps be assisted by making a transformation into some more or less approximate cost distribution for which again information beyond that of the statistician *per se* will be required.

On interpretation in general, therefore, few would disagree with Wiener (1948): 'The modern apparatus of the theory of small samples, once it goes beyond the determination of its own specifically defined parameters and becomes a method of positive statistical inference in new cases, does not inspire one with any confidence, unless it is applied by a statistician by whom the main elements of the dynamics of the situation are either explicitly known or implicitly felt'.

Other Statistical Contributions

A great deal of biological research can be considered in the formal pattern discussed in the previous section and one function of the controlled experiment is to provide a rational concentration of the process of learning from experience by the elimination of some factors and the local organization of others. This function may in fact be productive even when supported by the simplest quantitative assessment of results; for example a series of three factorially designed experiments, supported by simple ranking methods, were successful in finding a general growth medium for lactobacilli from among a very large number of possible combinations of media constituents and their concentrations (Cox and Briggs, 1954), a problem which one bacteriological colleague had described as impossible to solve!

Statistical contributions to biological research, however, extend widely beyond the relatively well understood controlled experiment. It has been stated previously that research proceeds from the known to the unknown and an important part of this process is often the quantitative determination of the known or the extant position in a given discipline and concomitantly the isolation of problems susceptible to controlled experimentation. The two methods available are the analyses of records and surveys, the former being usually extensive in time but local in space, the converse holding for sampling surveys. Apart from inevitable questions of interpreting the findings according to the circumstances in which they were collected, records mainly involve problems of analysis and it is sometimes surprising to find that these are undertaken with marginal statistical assistance. It is even more surprising, though now less common, to find that enquiries euphemistically described as surveys are embarked on with minimum, if any, statistical collaboration until assistance with the analysis of results is required. Such enquiries may be so easily biassed by circumstantial and subjective factors that any quantitative findings will be of dubious validity and ephemeral interest. There can be little doubt that the value of such surveys would be greatly enhanced by the preliminary assimilation of clear and well established statistical principles now available for both design and analysis. Questions of interpretation and inference corresponding to those for controlled experiments also arise with analyses of records and surveys and for non-experimentally obtained data the subject has recently been examined by Wold (1956).

Another general contribution of statistics arises in the collation of results obtained in separate experiments. In many cases such results, from series of experiments at one centre or from almost independent experiments at separate stations, have analogies with individual points on a graph and a statistical collation aims at defining a more complete curve which will assist in practical applications and towards the proper scientific ideal of elucidating principles rather than the 'cataloguing of phenomena' (Pearce, 1956). Although a number of such collations could be cited (examples: Yates, Boyd and Pettit, 1942; Cox, 1952) it is to be suspected that many more could profitably be made as essentially desirable preliminaries or stepping stones in a wide variety of biological research projects.

The dependence of research progress on experimental techniques has been mentioned previously; in one biological case, for example, it was found desirable to clarify the meaning of the term 'threshold' for which 'minimum detected concentration' was suggested (in Balmain *et al.*, 1954) to emphasize this dependence. On their introduction some new techniques, such as those involving radioactive isotopes, are so successful that formal appraisal is superfluous. Later, however, as these techniques become exoteric, assessments of their value in individual fields of research are required. Examinations of variability and its relation to the order of effects under investigation form an essential part of this evaluation.

The residual variation, or noise, from among which the effects of treatments need to be discriminated, usually contains what may be termed technical variation

arising from observational methods and their interactions with biological material, together with the 'natural', sampling, variation of the latter in proportions depending on the objects of an experiment and its design. Biologists are understandably reluctant to divert effort into refining techniques until the accompanying variation becomes a restriction on progress. Uniformity trials are accordingly rare and may even be less valuable in some cases than assessments of accuracy obtainable from the combination of variance estimates from series of experiments (for example, Armitage and Ingram, 1958) together with related estimates of desirable sample sizes. In addition to the study of variability *per se*, the comparison of alternative techniques in research has itself been recently placed on a statistical basis (Bradley and Schumann, 1957). And when such assessments can be supported by experiments on the techniques themselves (operational research), improvements in precision may be obtained; for example, Clarke *et al.* (1956), found it possible to reduce by 70 per cent the variance affecting determinations on the titratable acidity of milk.

The above paragraphs are not, of course, exhaustive, but though dealing with general applications of quite elementary methods may suffice to show that the fundamental contributions of statistics in biological research extend far beyond applications in controlled experiments. Such contributions may be expected to increase greatly as rapid modern developments in statistical theory become assimilated.

Wider Aspects of Biometry

The previous sections have detailed some applications to biological research of but one branch of mathematics whereas plainly the term biometry has far wider implications: 'He (the morphologist) may come to realize that there is no branch of mathematics, however abstract, which may not some day be applied to phenomena of the real world'. (Attributed to Lobachevski in Thompson, 1948).

And in fact, as indicated in Butterfield (1957), for example, the ancient mathematicians quite commonly and with no special sense that this was an extraordinary activity, applied their resources to biological investigation. The disciplines have since diverged and through the ages, despite some remarkable successes, subsequent applications have been only sporadic; no continuous tradition of mathematics in biology can be traced.

'So far as mathematical biology is concerned, my impression is that the accomplishments are not well known and that their influence on biometry falls short of what it might be.' (Cochran, 1949).

In this highly relevant and well moderated paper Cochran considers reasons for the deficiency arising in the attitudes and trainings of some biologists. The graduating studies in many biological disciplines, for examples, agriculture and biochemistry, are largely fact-accumulative where memory rather than the capacity to apply principles may be at a premium and correspondingly there is less time to develop an appreciation of research principles and methods with which the whole of a physics course, for example, is imbued. Memory and research ability are not necessarily positively correlated and, additionally, if some biologists have become so qualified partly to avoid more mathematical pursuits it does not seem unreasonable to find this motive preserved in their later studies. An analogous converse no doubt obtains among mathematicians. Finally it may be speculated that mathematical applications in biology were greatly hindered when they encountered the inevitable and characteristic variation previously discussed and to which developments in statistical theory have only recently provided the key. Accordingly we may note with enthusiasm specifically biometrical research—in fundamental bacteriology for example—McKendrick and Pai (1911), Armitage (1952), Powell (1958), and the appearance of books such as Kempthorne *et al.* (1954), Smith (1954). In spite of such advances what one misses in many biological journals is that permeation by quite elementary mathematics characteristic of the so-called 'exact sciences' which indicates the quantitative rather than the taxonomic approach. There are, however, some more encouraging signs in the strangely belated development of biophysics as a homogeneous discipline comparable to biochemistry and exemplified in the appearance of its own journals and textbooks, for example Bull (1943), Stacy *et al.* (1955).

Many of the basic questions of mathematics and, hitherto, particularly of statistics, in research turn on the use of mathematical models. In the analyses of experiments elementary models, with the accompanying theory of linear estimation, have proved of tremendous value in the detection and estimation of 'main effects' but what seems now to be needed are comparable developments in the elucidation of processes—using this term rather than 'causes' to avoid teleological discussion (but see Von Mises, 1957 and Russell, 1948 Chapter IX). And it is suggested that the mathematical formulation of processes, embodied for example, in differential equations and supported by initial conditions or estimates of the quantities involved, will constitute the next phase of biometric research. One aspect of science progress may, in fact, be regarded as the increasing refinement of mathematical models; initially, when large differences are involved, a crude approximation will yield results sufficient for practical purposes but, for finer discriminations, models will need to be more relevant to the underlying biological processes. Laws of diminishing returns may apply to such refinement processes and in some cases empirically descriptive models may even give the higher 'local' precision; more veridical models may, however, be generally expected to give better predictions (in the sense of, not necessarily temporal, extrapolations beyond immediate circumstances) and these are the essential objects of science (c.f. Brody, 1945). The powers and advantages of linear models have always been dependent on, and therefore restricted by, their computational simplicity and, now that individual

design applications have been subsumed under a general theory of linear estimation, modern developments in the field of electronic computation are remarkably opportune. Following its release from the above restrictions widespread advances in biometry should become possible, involving a shift of emphasis from formal analyses to investigations of the relevance and consequences of alternative hypotheses concerning biological phenomena. By permitting computational solutions of functional rather than linear models, electronic calculating machines can introduce mathematics and not simply statistics into research and it may accordingly be expected that some form of electronic computer should become standard equipment for any forward-looking research station concerned with fundamental biology.

Future Possibilities

Developments of the kind just discussed may be regarded as formidable if not intimidating by biologists concerned with pursuing research within carefully preserved boundaries.

'They're specialists, the whole lot of them . . . Modern research demands that every special branch shall dig in its own hole. It's not usual for anyone to sort out what comes up out of the holes and try to put it together.' Heyerdahl (1950).

Nevertheless inter-disciplinary studies continue to develop and they must, at any rate initially, depend on collaboration: 'Mr. Justice Lloyd-Jacob, suggesting that the most promising areas for future scientific growth are those that lie between the well-established scientific fields, stressed the importance of collaboration of the right kind if these fields are to be developed, what is wanted, he suggested, is not so much the skill to experiment in the field of another scientist, but the competence to understand, to criticise and to appreciate the experiment and the results that the experiment secures. Upon such lines the most useful team-work was done during the War . . . ' (Brightman, 1954).

These remarks are vitally appropriate for biometry and the desirability of collaboration is recurrently stressed (for example Finney, 1956, and discussion contributors) by statisticians. Biologists have been noticeably more reticent and wide differences in biometrical awareness still exist. That this is still true makes the enlightened encouragement given to statistical studies at Rothamsted in the 1920's quite remarkable—how many research advances, particularly in agricultural science and practice, are indirectly due to the exceptional perspicacity of Sir John Russell?

An appreciable proportion of current biological research is carried out by teams of workers involving contributions from specialists in particular experimental techniques such as, for example, chromatography and tracer methodology; the full time collaboration in such teams by biometricians is, however, usually limited by their small number in relation to the wide general requirements of statistics in research. This, together with the spate of statistical literature (now estimated at 1,000 papers per annum—Kendall, 1958) shows that some degree of specialization in particular biological fields is becoming essential if biometricians are to make their fullest contributions into research. In complement, an increasing mastery of the more elementary quantitative concepts may reasonably be sought among biologists. To assist in the latter respect monographs on elementary statistical methodology with emphasis on the interpretation of examples, in *particular* biological disciplines, seem now desirable. Books based on the agricultural idioms of field plot experimentation are of proved value but require a dual process of assimilation by many non-agricultural biologists. It is further suggested that—given accuracy in the exposition of the statistical principles—reviews of such books should be asked of the appropriate biologists themselves to balance reviews beginning with the familiar terms of deprecation—'Here is yet another undistinguished and elementary text . . .'.

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REFERENCES

Andrade, E. N. da C. (1956). An Approach to Modern Physics. G. Bell and Sons, London.
Anscombe, F. J. (1948). The validity of comparative experiments, J.R. statist.Soc., A, **111**, 181-211.
Armitage, P. (1952). The statistical theory of bacterial populations subject to mutation. J.R.statist.Soc., B, **14**, 1-44.
Armitage, P. and Ingram, G. I. C. (1958). Variability of blood-clotting tests. Applied Statistics, **7**, 1-14.
Bailey, N. T. J. (1952). The scope of medical statistics. Applied Statistics, **1**, 149-162.
Balmain, J., Cox, C. P., Folley, S. J. and McNaught, M. L. (1954). The bioassay of insulin *in vitro* by manometric measurements on slices of mammary glands. J.Endocrin., **11**, 269-276.
Beveridge, W. I. B. (1950). The Art of Scientific Investigation. William Heinemann Ltd., London.
Blackett, P. M. S. (1948). Operational research. Advanc.Sci., **5**, 26-38.
Bowra, C. M. (1957). The Greek Experience. Weidenfeld and Nicolson, London.
Bradley, R. A. and Schumann, D. E. W. (1957). The comparison of the sensitivities of similar experiments: applications. Biometrics, **13**, 496-510.
Brightman, R. (1954). The amateur scientist in Britain (2). Nature, **173**, 609-612.
Brody, S. (1945). Bioenergetics and Growth. Reinhold Publishing Corporation, New York.
Bull, H. B. (1943). Physical Biochemistry. John Wiley and Sons, Inc., New York.
Butterfield, H. (1957). The Origins of Modern Science. G. Bell and Sons, London. (2nd Edn.).
Clarke, P. M., Garvie, E. and Posener, L. (1956). The precision of the estimated titratable acidity of milk. Dairy Ind., **21**, 544-546.
Cochran, W. G. (1949). The present status of biometry. Biometric Society Congress, Geneva.
Cox, C. P. (1952). Changes with temperature in the viscosity of whole milk. J.Dairy Res., **19**, 72-82.
Cox, C. P. (1958). Analysis of Latin squares with individual curvatures in one direction. J.R.statist.Soc., B, **20**, 193-205.
Cox, C. P. and Briggs, M. (1954). Experiments on growth media for lactobacilli. J.App.Bact., **17**, 18-26.
da Vinci, L. Reference supplied by Dr. G. W. Scott Blair.
de Beer, J. *et al.* (collected papers) (1950). The place of statistical methods in biological and chemical experimentation. Ann.N.Y.Acad.Sci., **52** (Art. 6), 789-942.

(*Concluded on page* 139)

THE PREPARATION OF HIGHER BOILING ALKYL BROMIDES USING HYDROBROMIC ACID

by C. C. T. Chinnick

ALKYL bromides may be prepared from the corresponding alcohols by the action of various reagents, including hydrobromic acid (Norris, 1907; Norris, Watt and Thomas, 1916; Norris and Mulliken, 1920; Kamm and Marvel, 1920), hydrogen bromide (Guyer, Bieler and Hardmeier, 1937; Organic Syntheses 1943a) phosphorus tribromide (Organic Syntheses, 1943b) thionyl bromide (Frazer, Gerrard, Mackell and Shepherd, 1954) and tri-cresyl phosphite dibromide (Coe, Landauer and Rydon, 1954). Of all these reagents hydrobromic acid is undoubtedly the cheapest and most easily available. It has been generally agreed, however, that although secondary and tertiary alcohols react readily with hydrobromic acid to give good yields of alkyl bromides, primary alcohols react only very slowly and give poor yields.

Experiments were therefore carried out to see if the yield of primary alkyl bromides could be improved by the addition of catalysts. The addition of zinc bromide or phosphoric acid had very little effect but sulphuric acid increased the yield to over 90 per cent in agreement with the findings of Kamm and Marvel. The results obtained by refluxing myristyl alcohol with hydrobromic acid with and without the addition of catalysts are shown in Table I.

TABLE I

Gram mols HBr / *Gram mols alcohol*	*Catalysts*	*Time of reflux (Hours)*	*Yield* %*
1	None	2	44·9
2	None	2	63·2
4	None	2	77·9
2	None	6	66·5
2	2 Gram mols H_2SO_4	2	93·4
2	2 Gram mols H_3PO_4	2	70·3
2	1 Gram mols $ZnBr_2$	2	66·7

*The product was a light brown oil in all instances except when sulphuric acid was used when a dark red-brown oil was obtained.

It was thought that in the preparation of alkyl bromides with boiling points over 100°C., it should be possible to distil off the excess water present in the reaction mixture and thus increase the yield. As constant boiling (48 per cent) hydrobromic acid contains 4·9 gram molecules of water for each gram molecule of hydrogen bromide, the quantity of water to be removed from the reaction mixture would be 5·9 gram molecules for each gram molecule of alkyl bromide produced. Using a flask fitted with a fractionating column it was found that water containing a small amount of hydrobromic acid could be distilled from the reaction mixture. In Table II are given the results of two experiments in which myristyl alcohol was reacted with different amounts of hydrobromic acid.

TABLE II

Gram mols HBr / *Gram mols alcohol*	*Time of Distillation (Hours)*	*Distillate collected Gram mols water* / *Gram mols alcohol*	*Yield* %*
2	4·5	5·0	85·3
4	4·5	5·5	92·3

*In each case the product consisted of a light brown oil.

The method was then applied to other straight and branched chain primary alcohols using 4 gram molecules of hydrobromic acid for each gram molecule of alcohol, and the results of these experiments are given in Table III.

It can be seen that for the primary straight chain aliphatic alcohols from octyl to stearyl, the yield of alkyl bromide is almost constant, 91·5-93·0 per cent. This figure compares very well with the 93 per cent yield obtained in the sulphuric acid process. For three branched chain primary alcohols yields of 95·5-97·1 per cent were obtained, while a fourth alcohol yielded 84·1 per cent. Thus the method is of general application to the synthesis of higher boiling primary alkyl bromides from the corresponding alcohols.

The distillation technique can be shown to have several advantages over the sulphuric acid method. When sulphuric acid is used the alcohol which is not converted into alkyl bromide is lost in the formation of by-products, whereas in the distillation method the unreacted alcohol remains unchanged and is usually recoverable. In the sulphuric acid method the excess hydrobromic acid used is usually lost because it is not easily recoverable, but in the distillation method, the aqueous layer in the reaction flask contains 48 per cent hydrogen bromide and after separating from the alkyl bromide layer can be used in another reaction without further treatment.

The crude alkyl bromide, being only slightly coloured and containing only a few per cent of alcohol as impurity, can, in many instances, be used without purification. If the pure alkyl bromide is required, however, the alcohol can be removed by washing with

TABLE III

Alcohol	*Formula*	*Yield** %
Octyl	n—$C_8H_{17}OH$	91·8
Decyl	n—$C_{10}H_{21}OH$	93·0
Lauryl	n—$C_{12}H_{25}OH$	92·3
Myristyl	n—$C_{14}H_{29}OH$	92·3
Cetyl	n—$C_{16}H_{33}OH$	92·1
Stearyl	n—$C_{18}H_{37}OH$	91·5
2-Ethyl-hexyl	C_4H_9 / C_2H_5 >$CHCH_2OH$	96·8
'Nonanol'**	CH_3—CH(CH_3)-CH_2-CH(CH_3)-C_2H_4OH	97·1
'Alphanol 79'**	C_7—C_9 alcohols	95·5
'OXO' C_{12}—C_{14}***	C_{12}—C_{14} alcohols	84·1

*In each case the product consisted of a light brown oil.
**Both of these alcohols are products of Imperial Chemical Industries Ltd.
***A primary alcohol mixture, the structures of which are not exactly known, produced by Shell Chemicals Ltd.

cold 90-95 per cent sulphuric acid, and after further washing with water, sodium carbonate solution and water, the product may be distilled, usually under vacuum.

It has been found, however, that for the primary straight chain aliphatic bromides, a better method of removing the unreacted alcohol is by extraction with aqueous methanol. The aliphatic alcohols are easily soluble in aqueous methanol whereas the corresponding bromides are only very slightly soluble. Alkyl bromides become increasingly soluble in aqueous methanol as the alkyl chain length decreases, but an increase in the water content of the solvent depresses the solubility while the corresponding alcohols remain appreciably soluble. For example, 100 g. of 75-25 methanol-water mixture will dissolve, at 40°C., about 1·5 g. of octyl bromide, but over 100 g. of octyl alcohol. Similarly, 100 g. of 98-2 methanol-water will dissolve, at 40°C., about 2 g. of stearyl bromide but over 100 g. of stearyl alcohol. The recommended concentrations of methanol-water mixtures for extracting, at 40°C., the unreacted alcohol from a primary aliphatic alkyl bromide reaction product are given in Table IV.

It has been found that extraction of 100 g. of crude alkyl bromide, containing about 7 per cent of the corresponding alcohol, with three one-hundred millilitre portions of aqueous methanol removes all but a trace of the alcohol. The alkyl bromide can then be

TABLE IV

Alkyl bromide—alcohol mixture	*Methanol-water by volume*
Octyl	75—25
Decyl	80—20
Lauryl	85—15
Myristyl	90—10
Cetyl	94— 6
Stearyl	98— 2

distilled or stripped of any remaining methanol and water and used direct. Evaporation of the extract leaves a residue of alcohol and alkyl bromide which can be utilized in the preparation of another batch of alkyl bromide.

Experimental

Reflux Experiments.—In a one litre flask equipped with a stirrer and reflux condenser were placed 214 g. (1 mol) of myristyl alcohol and the required amount of 48 per cent hydrobromic acid and catalyst, if any. The mixture was stirred under reflux for the stated time and after cooling the layers were separated. The organic layer was dissolved in 250 ml. of benzene and washed with 2 × 500 ml. of water. The benzene was distilled off and the last traces removed by heating under vacuum for a few minutes. The product was analysed for bromine by the method described below. The results of these experiments were shown in Table I.

Distillation Experiments.—The apparatus used was the same as above except that the reflux condenser was replaced with a 2 × 15 cm. fractionating column packed with glass rings and surmounted by a reflux-distillation head. Thus the mixture could be refluxed for a while before distillation began. The apparatus was charged with 214 g. (1 mol) of myristyl alcohol and the stated amount of hydrobromic acid. In the first two experiments (see Table II) using myristyl alcohol, the mixture was refluxed for two hours and then distilled for two-and-a-half hours. In the experiments on other alcohols variations in these times were tried and it was found that half-an-hour's refluxing was sufficient. After cooling the reaction mixture the alkyl bromide layer was dissolved in benzene and washed with water as described above.

The bromine content of the crude alkyl bromides was determined by refluxing a weighed sample with sodium in amyl alcohol followed by titration of the ionizable bromide with standard silver nitrate solution.

REFERENCES

Coe, Landauer, and Rydon. (1954). J.C.S., 2281-8.
Frazer, Gerrard, Mackell, and Shepherd. (1954). Chem.and Ind. July 24, 931-2.
Guyer, Bieler, and Hardmeier. (1937). Helv.Chim.Acta, 20, 1462-7.
Kamm and Marvel. (1920). J.A.C.S., 42, 299-309.
Norris. (1907). Am.Chem.J., 38, 627-42.
Norris, Watt, and Thomas. (1916). J.A.C.S., 38, 1071-9.
Norris and Mulliken. (1920). J.A.C.S., 42, 2093-8.
Organic Syntheses (1943 a). Coll.Vol.II, 246.
Organic Syntheses (1943 b). Coll.Vol.II, 358.

NEW DEVELOPMENTS IN THE PHYSICAL CHEMISTRY LABORATORY

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PART II—MUTUAL SOLUBILITY DETERMINATION IN PHENOL-WATER MIXTURES

THE determination of mutual solubilities in two-phase liquid systems is carried out regularly in practical physical chemistry in the B.Sc., A.R.I.C. and H.N.C. courses. The phenol-water system is used as an example and is quoted extensively in practical physical chemistry text-books. Phenol is, however, an irritant and corrosive agent and because of this it is advisable to place the phenol-water mixtures in stoppered tubes or sealed glass tubes. The latter system, adopted in this laboratory, has the advantage that once prepared the sealed contents can be kept for long periods, thus avoiding the necessity for repeated preparations by students. Such preparations occupy a good proportion of the student's time (without sufficient recompense) which could be employed far more usefully in carrying out further experiments. This consideration is important, as the time allotted for practical physical chemistry is comparatively small and it is essential to reduce such wastage to minimal proportions.

Now, even the initial preparation of phenol-water mixtures requires nine individual weighings of phenol, and despite warnings and supposed care by the students who carry out the weighings, it is common to find that balances in which phenol has been weighed, afterwards reek of it. The presence of phenol or its vapour results in greatly increased corrosion of metal surfaces, and hence any weighings should be reduced in number as far as possible. The author has therefore developed the following method which involves only a *single* weighing of phenol, followed by a preparation of a *stock* solution of phenol-water, which when mixed with water in the right proportions gives the required phenol-water mixtures. This method has a further advantage in that the preparation of the phenol-water mixtures in sealed glass tubes is made simpler because the introduction of solid phenol through glass constrictions is avoided.

(*a*) *Preparation of stock solution containing* 80 *per cent phenol* (or more) by weight.***—It is possible to make a *homogeneous* stock solution of phenol and water which contains a high proportion of phenol by mixing a weighed quantity of phenol with a measured volume of distilled water to a *known* final volume of *homogeneous* solution i.e. in a volumetric flask. The ratio of the weights of phenol and water must be such as to be outside the two phase area of the system.

An alternative method is to weigh out a given quantity of phenol and add it to a known volume of water as in the previous method (also preserving the ratio requirements), but instead of measuring the final volume, the density of the solution is determined using an accurate hydrometer.

Whichever method is used, we have for the *stock* solution

mass of phenol (π) + mass of water (m) = volume of solution (v) × density of solution (d)

i.e. $\pi + m = vd$ ..... (1)

Let the phenol-water stock solution contain per c.c. 'p' g. of phenol and z g. of water, then on adding w ml. of distilled water to y ml. of *stock* solution, we have a *total* of $(w + yz)$ g. water plus (yp) g. phenol.

Hence, the phenol percentage composition *by weight* is

$$P = \frac{yp}{(w + yz) + yp} \times 100 \quad \ldots\ldots (2)$$

The water percentage composition can be similarly equated or be put equal to (100—P).

In order to be able to use the last equation we must substitute into it the known data. Rearranging it we have

$$w = \frac{100yp}{P} - y(z+p) \quad \ldots\ldots (3)$$

Now, $(z + p) = d$ ..... (4)

Hence, equation (3) can be rewritten as

$$w = \frac{100yp}{P} - yd \quad \ldots\ldots (5)$$

Now, by definition, $p = \pi/v$ ..... (6)

Also, rearranging equation (1), we obtain

$$v = \frac{\pi + m}{d} \quad \ldots\ldots (7)$$

Substituting the above value into equation (5), we have

$$w = \frac{y\pi d\ 100}{(\pi + m)\,P} - yd \quad \ldots\ldots (8)$$

$$= yd \left\{ \frac{100\ \pi}{P(\pi + m)} - 1 \right\} \quad \ldots\ldots (9)$$

Now π, m and d have been evaluated. Therefore, if the value of P be fixed for a given tube, and the total volume of $(w + y)$ be stated, the respective values of w and y can be calculated.

(*b*) *Preparation of the tube containers.*—Ordinary soda glass tubes, c. 15 cm. long and 1·7 cm. diameter* are drawn in the flame to a shape given in Fig. 1. It is advisable to draw more tubes than the number of solutions required so as to allow for breakages and for storage until required.

*The phenol should be of analytical purity.

**A solution containing 80 per cent, or more, phenol by weight is outside the two-phase system, i.e. it is homogeneous.

*The tubes should be thoroughly cleaned and dried. *See* Lewin (1956). In order to seal the tubes neatly and easily after running in both liquids, it is necessary to draw the tube comparatively finely. However, the finer the capillary is drawn, the more difficult it is to introduce the stock solution and the water. In practice, a compromise is reached by making the diameter of the capillary about 2 mm.

Fig. 1. Drawn tube.

(*c*) *Preparation of the individual mixtures.*—One burette containing distilled water and one burette containing the *stock* phenol-water solution are required.

The stock solution should be run first into the cup of the drawn tube, the water being less viscous flows down more readily after washing down the stock solution. Now, the liquid in the cup rarely flows down completely on its own, owing to the narrowness of the diameter of the capillary joining the cup with the rest of the tube. Hence, it is necessary to use a 'cold-hot' method, i.e. the tube is changed alternately from hot surroundings to cold ones—such as beakers containing hot and cold water respectively—until all the liquid has entered the tube. Once this has been achieved, the tube is sealed off in a flame.

The prepared sealed glass tubes may now be placed individually in a beaker of water the temperature of which is usually regulated by heating with a bunsen. Now, the temperature of the contents of the sealed tube cannot be recorded *directly*, but is usually assumed to be equal to that of the surrounding water. Provided that the temperature of the water in the beaker is altered very slowly and efficient stirring of the contents of the tube takes place continuously, the temperature difference between the contents of the tube and that of the surroundings can be kept at *less* than 0·1°C. which represents the average experimental error limit in students' practical physical chemistry. The procedure adopted in the past in this laboratory has been to stir the contents of the sealed tube by vigorous manual *vertical* stirring, while the surrounding water was stirred using an electric motor. The vertical stirring was effected by the use of a simple glass stirrer bent at the bottom to form part of a circle which was covered with rubber tubing. The sealed glass tube was placed on the rubber bed and attached by suitable metal wire to the main stem of the stirrer.

This technique was modified sometimes to include a pulley plus string arrangement which decreased its tediousness. Lately however other procedures have been adopted which dispense altogether with the manual stirring. One method is to place the sealed glass tube in a special arrangement which is fixed into the stirring rod part of the electric motor used for stirring the surrounding water. The other is to employ a simple arrangement using a magnetic stirrer. The latter method when finally developed was found to operate very efficiently. The technique adopted is to use a small length of rubber tubing into which the lower part of the sealed glass tube can be gently forced and then strongly held. Two holes, opposite to one another, somewhat smaller in cross-sectional area to that of the stirring magnet are cut in the rubber tube section so as to place the magnet about 3 to 5 mm. below the lowest part of the sealed glass tube (held inside the rubber). This ensures that any sudden downward compression of the rubber tubing will not result in damage to the bottom of the tube by the attached stirring magnet (Fig. 2). For efficient stirring the following points should be observed:

(*a*) The holes cut should not be higher than c. 2 to 3 mm. above the bottom of the rubber tubing. This is so because the efficiency of the magnetic stirring decreases very rapidly with decrease in magnetic field intensity between the external stirring magnet and the driver magnet attached to the electric motor.

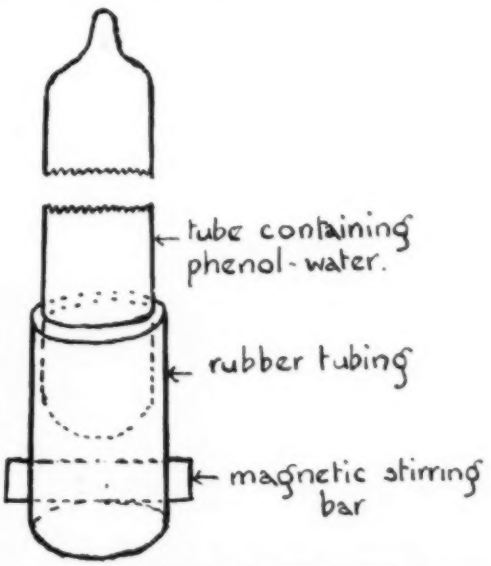

Fig. 2. Magnetic stirring arrangement.

(*b*) The bottom of the rubber tubing should be evenly cut.

(*c*) The length of the stirring magnet should be effectively greater than the diameter of the rubber tubing. For the glass tubes of the diameter used—c. 1·7 cm. the length of the stirrer should be 2·5 cm. or more.

(*d*) The level of the water in the beaker should be at least 2 to 3 cm. above that of the top of the sealed glass tube when placed in the rubber tubing ready for stirring.

(*e*) A rubber sleeve made of the same diameter rubber tubing as used above should be gently forced on to the *top* of the sealed glass tube. This will decrease the chances of damage owing to accidental shocks on the sides of the beaker.

The water surrounding the sealed glass tubes has of course to be heated* to a temperature above that of the particular two-phase system. This is usually carried out by the use of a bunsen burner. However, the use of a magnetic stirrer requires close proximity of the beaker to the driver motor, and this precludes the use of the bunsen. It is therefore necessary to use a micro-burner, to heat the beaker, sideways in a slightly tilted position; alternatively the heating may be carried out using electrical systems such as nickel chrome wiring round the beaker, or using combined magnetic stirrers plus hot plates and simmerstats. These methods are satisfactory, but the last mentioned was found more convenient.

The time saved by the adoption of the above complete technique, viz. the use of ready sealed tubes and magnetic stirring is considerable. It has been estimated that carrying out the overall experiment using 12 points along the miscibility curve and weighing the phenol separately for each tube resulted in the average student requiring as much as ten hours for completion. But with the sealed tubes available and with the magnetic stirring technique adopted only about four to five hours were required.

The adoption of the sealed tube technique is advisable for other reasons such as the elimination of phenol vapour during the miscibility point measurements. As should be appreciated, corrosive vapours should be absent from the atmosphere in a physical chemistry laboratory to avoid attack on balances and other expensive apparatus. This point is often overlooked.

(*To be continued*)

*The co-solubility temperature of the two-phase system is best determined by raising the temperature of the system above the correct value, allowing it to cool slowly and noting the temperature at which opalescence begins, this phenomenon signifying the formation of a two-phase system.

Warren Spring Laboratory

The Lord President of the Council (Lord Hailsham) will open the new Warren Spring Laboratory, D.S.I.R., at Stevenage, on Monday, June 29, 1959.

The new laboratory is intended to assist Government departments and industry by resources that are not available in any other establishment of the Department. It will carry out research and development in a wide field and will not be limited to particular aspects of technology. Its initial programme will include work on mineral processing, the synthesis of oils and chemicals from carbon monoxide and hydrogen, and research aimed at the suppression of atmospheric pollution. Much of this work will be of a chemical engineering character and will require basic chemical engineering research to be undertaken in parallel with it.

For the time being, research on atmospheric pollution will continue at Greenwich, where the address is The Atmospheric Pollution Division, Warren Spring Laboratory, River Way, East Greenwich, London, S.E.10.

Radioactive Isotopes

To meet the increasing demand for radioactive isotopes and to continue to improve their service to users throughout the world, the U.K. Atomic Energy Authority announce a reorganization of the isotopes production and marketing which has hitherto been shared between the Radiochemical Centre at Amersham and the Isotope Division of A.E.R.E. Harwell.

It has been decided to widen the scope of the Radiochemical Centre to form a single comprehensive organization for producing and marketing all such isotopes.

The Radiochemical Centre has its headquarters and principal laboratories at Amersham and will have irradiation facilities at Harwell and at other Authority sites.

Dr. W. P. Grove is appointed Director of the reorganized Radiochemical Centre.

The reorganization is already effective, but users of radioisotopes should continue, until they are advised of new arrangements, to order their requirements from Amersham or Harwell as they have done in the past.

Research into the properties of isotopes and new applications of them and their radiations will be continued by an Isotope Research Division at Harwell and at the Wantage Radiation Laboratories.

The Association of Consulting Scientists

The formation of the Association of Consulting Scientists is announced. The main purpose of the Association is to act as a clearing bureau for enquiries for independent scientific services. Membership of the Association embraces independent whole-time Consulting Scientists in the U.K. in all fields of science and technology other than medicine and civil, mechanical and electrical engineering. The founding members are mostly chemists and biologists, but physics and other sciences are expected to have representation in the new Association before long.

At a meeting held in London last spring under the Chairmanship of the late Sir Hugh Watts, it was decided to explore the possibilities of such an Association and at a more recent meeting inauguration was formally completed.

Discussion at the meetings referred to was particularly concerned with the present inadequate appreciation and utilization in the U.K. and overseas of existing research and other facilities available from independent British Consulting Scientists and Research Institutes.

The new Association will operate in close collaboration with the Royal Institute of Chemistry, and other professional institutes and with other organizations concerned with the co-ordination of British efforts in research, production and marketing.

The affairs of the Association are in the hands of an elected Committee, having the following Officers:

Chairman: J. G. Davis, Ph.D., D.Sc., F.R.I.C., M.I.Biol.,
Hon. Treasurer: G. W. Ferguson, B.Sc., Ph.D., F.R.I.C.
Hon. Secretary: W. H. Stevens, A.R.C.Sc., F.R.I.C., F.R.I., F.I.R.I.

Communications or enquiries should be addressed to the Hon. Secretary at 15 Hawthorne Road, Bromley, Kent.

PSYCHOLOGICAL ASPECTS OF LABORATORY WORK

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PART VII—SOME WIDER HUMAN PROBLEMS (SECTION 3)

Introduction

This is the final article in the present series. It will be necessary to combine the treatment of the few topics remaining to be considered with a résumé of the general implications of the whole series. Briefly, the following headings summarize what is to be included here:

1. Concrete examples of the use of systematic selection techniques in relation to laboratory work, with special reference to the role of various types of tests.
2. Comments on the assessment of personnel.
3. Comments on the evaluation of research performance.
4. General summing up, with reference to the whole series.
5. References to Parts V, VI, and VII.

Before taking up the first of these points, a few additional comments must be made about selection techniques in general. To recapitulate, these techniques cannot be judged fairly against perfectionist standards, for previously existing techniques cannot claim to have achieved perfection. The practical aim of systematic selection methods is to *reduce* misclassification. For this purpose information is required about the degree of misclassification both before and after the introduction of systematic methods. A small reduction in the number of misfits, or in 'labour-turnover' in certain occupational grades, could soon offset the cost of systematic selection methods, properly carried out. Of course, the immediate context is very important. Thus the principal problem nowadays with senior appointments is that of *finding* a suitable person rather than selecting one from a number of generally satisfactory applicants. The extensive use now made of sizable advertisements for scientific and technical appointments in 'The Observer' or 'The Sunday Times' is an indication of an important change of emphasis which has occurred during the last ten years. Hiscocks (1956, p. 76) made a relevant comment here when he stated that scientific appointments with salaries of £1,500 p.a. and over usually bring few (external) applications.

Systematic selection techniques are most useful when there is a substantial number of persons to be selected and when the number of applicants considerably exceeds the number of positions available. Perhaps this state of affairs is likely to be most apparent in the selection for higher scientific and technical education and in the initial appointment of trained personnel. However, in some fields the 'seller's market' for talent exists even at this early stage. In spite of these reservations a few concrete illustrations will now be given of tests in use for selection purposes connected with scientific and laboratory work.

Selection for Scientific and Laboratory Work

(*a*) *Scientific and Research Personnel.*—Comparatively few *published* examples seem to be available of the use of systematic selection methods for scientific and laboratory personnel. No doubt investigations are in progress, but no attempt has been made to circularize persons or organizations known to be interested in this work for up-to-date information. It is not intended to explore in this series the possibilities in the way of systematic selection techniques for higher education of a technological and scientific type. This might well be included in the psychological aspects of laboratory work, but would require a detailed study in its own right. It is worth noting here that 20 years ago Hiscock (1938) examined the use of tests for the selection of chemical process workers, in a U.K. plant. This may be a little removed from laboratory work, but it again indicates that the general question is not just arising for the first time.

The most relevant study hitherto noted is that of Shaycoft and Altman (1955) in which they discussed American experience in the use of tests for selecting scientists and research personnel. The work concerned was carried out under the general direction of Dr. J. C. Flanagan of the American Institute for Research, Pittsburgh. A special test was used and this was based upon the 'areas' of work previously classified by Flanagan (see Part V of this series). The test consisted of 150 questions having a 'multiple choice' type of answer and took about 3½ hours to administer. It was given to 917 students and 778 employees (mostly junior research personnel) in government and industrial research organizations. Expressed as a correlation coefficient the reliability of the test was at least 0·86. The correlation between performance on the original test and scores on a proficiency test taken one or two years later ranged from 0·41 to 0·64, although correlations with other possible indices of success were much lower.

For purposes of interpretation it is worth adding here that a test having a validity of 0·50—the correlation between test scores and some acceptable index of success at a later stage—could produce a considerable improvement in selection. Let us assume that prior to using this test 30 per cent of the applicants were accepted and that 15 per cent of these proved unsatisfactory. On actuarial principles, the use of the prescribed test would reduce the 'failure rate' or proportion of misclassifications from 15 per cent to 3 per cent of those accepted assuming that one continues to accept 30 per cent of all applicants and that their general characteristics are unchanged. For further information along these lines *see* tables prepared by Taylor and Russell (1939).

(*b*) *Tests of Colour Vision.*—Let us turn now to the first of two examples of screening in terms of tests of sensory functioning. In some cases wide deviations from normal colour vision may disqualify a person from a particular occupation; in others it will mean that certain tasks are outside his range. Available tests of colour vision vary greatly in their efficiency. If screening on the basis of normal colour vision is to take place at all then testing should be made in the most efficient manner possible. 'A review of some problems of colour vision and colour blindness' formed the subject of Prof. Pickford's Presidential Address to Section J (Psychology) of the British Association Meeting in Glasgow in the autumn of 1958. For precise work there is much to recommend the use of actual adjustment methods for testing colour vision in which one colour stimulus, whose spectral composition may be varied, may be adjusted to match another. Among the recent instruments developed in this field is an 'Anomaloscope' originating in the Ilford Research Laboratories, and a 'Four-colour Anomaloscope' described by Pickford (1957) and recently marketed. Confusion charts, of which the Ishihara Test is perhaps the best known, seem very much less satisfactory from a point of view of precision than the instrumental tests. Cavanagh (1955) reviewed a wide range of relevant information about the Ishihara Test and its use. In most instances the actual criteria for screening off an individual from a particular occupation or task are still very loosely determined and this offers another field for important psychological investigations in which test performance is to be related directly to performance on the task concerned. Flame tests, titration, visual colour matching, colour blending and the use of colour codes and signals have all been noted as tasks in which normal colour vision is important, but precisely how important? Selection problems in this field not only require 'occupational norms', but must also take into account the well known fact of important sex differences, for only about $\frac{1}{2}$ per cent of the female population depart seriously from 'normal' whereas between 6 to 9 per cent of the male population are so affected.

(*c*) *Taste and Odour Sensitivity.*—Some food technologists have attempted to select 'taste testers' on the basis of high sensitivity for taste and odours. Leaving aside the question of the reliability of the quantitative measurement of sensory thresholds, few investigations have been made to test the validity of high sensitivity to separate taste stimuli (substances) as an indication of the ability to assess the more complex characteristics of actual food products. Where this has been examined the conclusions seem to indicate very little relationship between these two types of skill or ability. Thus, for example, King (1937) found no relationship between measures of absolute thresholds for sweet, sour, salt and bitter substances and the ability to detect the same substances as constituents of bread. Earlier, Blakeslee and Salmon (1935) after testing a group of persons with a wide range of taste stimuli noted that the group formed '47 varieties of individuals'. On the other hand Hopkins (1946) was able to demonstrate a significant association between absolute sensitivity to several substances, although the association between sensitivity to bitter substances and to the other three hypothetical primary taste stimuli was strikingly lacking. Hopkins also was led to conclude that, except in extreme instances, there was no consistent relation between sensory acuity alone and the palatability scores given to dishes made with dried egg containing varying amounts of the same substances. More recently, Girardot and others (1952) have discussed specifically the selection of sensory testing panels. They, too, noted the very limited usefulness of sensitivity measurements on their own as a means of selection. In any case, there are good arguments against the advisability of using human screening devices which are far more sensitive or discriminating than the majority of consumers of the product under consideration. (*See* Harrison, 1952).

The Assessment of Personnel

Human performance includes many characteristics which cannot readily be measured by simple, objective methods. In all walks of life the assessment of personnel in something approximating very closely to plain, everyday language remains an indispensable task. This provides just one more example of the use of subjective assessment which cannot be eliminated and whose basic consistency and validity may be improved by standardization of procedures together with a greater knowledge and understanding of what is involved. One of the most common approaches is the use of a 'Rating Scale' which consists of a series of ordered categories (lettered or numbered) representing under selected headings graduated levels of performance. The meaning of the reference points may be sharpened up by using brief 'pen pictures'. The use of this type of 'scale' carries with it a number of possible sources of systematic bias which have been examined experimentally in various situations. It would take too long to catalogue and describe these here, but to know of their existence is the first step to avoiding them. Further useful information may be obtained from the chapter on Rating Scales in Guilford (1954). A more immediately practical examination of this question, with special reference to 'Staff reporting in a government department', has been reported by Anstey (1950) in a most informative manner. Hiscocks (1956) also discussed this question from the special standpoint of research organizations. He included valuable appendices in which are reproduced report-forms in current use in the U.S. National Bureau of Standards, the National Research Council of Canada and, in the United Kingdom, in the Department of Scientific and Industrial Research. Several papers in the Symposium on 'The Direction of Research Establishments' (H.M.S.O., 1957) may be consulted for further up-to-date reports of personal experience relating to the assessment of personnel and the evaluation of research.

The Evaluation of Research Achievements

As increasing amounts of public money are devoted to scientific research and as the scientific enlightenment of the layman proceeds, an increasing demand seems likely for the systematic evaluation of the achievements of research; especially those of collective research programmes. Certain developments in this field have no doubt already taken place, but it is at least safe to say that techniques have not yet been widely formalized on a rational basis. Advertisements have already appeared in the press for personnel to develop this type of work on behalf of at least one large research organization. It might be argued that industrial research will be more closely tied than other types to a profit and loss account, but even this will prove to be too sweeping a generalization (see below). The literature of psychology contains within it much good sense on the methodological problems relating to systematic assessment and it is doubtful whether there is any other alternative source of factual guidance on the available techniques. This information has probably never been condensed and translated in a manner appropriate to the non-psychologist and, as frequently argued in the present series of articles, the application of this knowledge to the problems of evaluating research is just another matter for special investigation. Recent source material directly concerned with this problem includes a report of American experience of 'Evaluating research and development' by Weschler and Brown (1953).

Reference may also be made here to several papers by Rubenstein (1955, 1957 a and b). These deal, respectively, with 'The evaluation of the possibilities of research effort in a new field of technology'; 'Setting criteria for research and development'; and 'Liaison relations between research and development'. These three papers are far too packed with interesting observations to do anything more here than pick off a few special items. In the first paper Rubenstein (1955) referred to the director of a Scandinavian research laboratory who directed his very limited resources to the study of two fundamental investigations which were only indirectly related to the company's business and had no promise of financial return for many years, if at all. The director's opinion was that in this way he would be in a better bargaining position to exchange information with other laboratories than if he had pursued a programme of short-term research of a less specialized type. The second paper referred to the fact (also quoted by Likert and Hayes, 1957) that useful practical generalizations can be obtained from broadly categorized data concerning the factors influencing research productivity. The specific example was drawn from a paper by Pelz (1956—not inspected in the original) in which it was established that groups of persons representing different scientific disciplines have a greater chance of achieving entirely new solutions to problems than groups consisting of persons working entirely in the same field. This example has bearing upon problems of human motivation, a most important topic which cannot be explored in detail. The third paper touched upon certain social influences in so far as it included a pictorial representation of the contrasting characteristics of 'the social structure' of a University and an industrial research group. The University group was characterized by an amorphous cloud of individuals (points) whose channels of communication and responsibility were freely and personally determined. The industrial group was represented by a neat block-diagram—a hierarchical structure with precisely defined and formalized channels of communication and responsibility. These diagrams are obviously over-simplifications of complex facts, but they contain sufficient of the truth to help these two groups to understand one another's special problems when concerned with mutual collaboration.

Summing Up

The time has now come to attempt to sum up the principal contributions of the whole series of seven articles. No single topic has been dealt with really comprehensively, although some have been treated in greater detail than others. Those selected for intensive treatment, such as the psycho-physical methods and their application (*see* Part IV) have simply represented the special personal interests of the writer. Every attempt has been made *not* to be dominated solely by personal interests and, looking back, it seems reasonable to claim that a representative picture has been sketched out of the range of psychological aspects of laboratory work. In some instances, one region has been more fully and clearly delineated simply because there are more actual investigations to summarize. Thus, for example, the topic of design of scales and controls has behind it a rapidly accumulating body of literature and a number of developing experts. In contrast, in the United Kingdom at least, the available material on systematic selection procedures directly relating to laboratory work is very thinly spread. The same remark also applies to the established facts concerning the wider, human aspects of laboratory work.

No useful purpose would be served here by re-cataloguing the various topics which have been touched upon or by summarizing these further. It may be recalled that the aims of the present series were made explicit in the first article in the following words:

> 'To provide a representative outline of the types of problems arising in laboratory work and upon which existing psychological knowledge and techniques may throw a new light.'
>
> 'To develop a few selected examples in sufficient detail to illustrate how existing psychological knowledge and techniques may be adapted to the problems of laboratory work.'

Although ideas have changed and developed in the course of writing and there is no absolute guarantee that the final version will conform exactly with the original intentions, the series as a whole still seems to satisfy these aims. Primarily this has been an orientation exercise. Ample references both to standard texts and to a selection of journal literature have been given for the

interested reader to follow up any special points of interest. A more detailed analysis of specialized psychological topics would hardly be appropriate to this journal unless such articles reported original investigations of problems arising specifically from laboratory practice. In the main, these are yet to be carried out.

ADDENDUM.—Two books and one additional research contribution, all originating from Cambridge, have been examined since the MS of this series of articles was completed. In one chapter of a book entitled 'Perception and Communication' (1958) Broadbent, who is now Director of the Medical Research Council's Applied Psychology Research Unit, has assembled an up-to-date review of the effects of noise on human behaviour. This includes a brief note on 'practical conclusions'. Another chapter in the same book deals with 'The General Nature of Vigilance' a conception brought into Part III of the present series when dealing with routine laboratory observation. The other book is 'Ageing and Human Skill' by Welford (1958). Apart from general observations on this theme the main body of the book gives a survey of experimental work carried out between 1946 and 1956 by the Nuffield Unit for Research into the Problems of Ageing, of which Welford was at that time Director. As noted on several occasions previously, it is primarily the implications of such investigations rather than their *immediate* application to laboratory tasks which merits attention here. The whole approach forms an admirable contrast to Lehman's approach to the problems of 'Age and Achievement' discussed in Part V of this series of articles. A preliminary note by Gross and Hudson (1958) is the last additional item noted here. These two authors have recently examined undergraduate records of present Fellows of the Royal Society who took their relevant examinations either at Oxford or Cambridge prior to 1939. An interesting comment is thus forthcoming upon the predictive value of undergraduate performance as an early indication of this particular form of creative scientific achievement. Of those Fellows of the Royal Society who graduated between 1920 and 1939, 1 in 4 from Cambridge and 1 in 3 from Oxford gained either 'a second' or 'a third' at some time in their undergraduate career.

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REFERENCES

Article V
Broadbent, D. E. (1953). Q.J.exper.Psychol., **6**, 1-5.
Broadbent, D. E. (1957). Ergonomics, **1**, 21-29.
Crocker, E. C. (1945). 'Flavour'. McGraw-Hill Book Co. Inc., New York.
Flanagan, J. C. and others (1949). 'Critical Requirements for Research Personnel'. (Mimeographed) American Inst. for Res., Pittsburgh, Pa.
Hopkinson, R. W. (1958). In Symposium. Nature, Lond. **181**, 90-91.
Kryter, K. D. (1950). 'The Effects of Noise on Man'. J. Speech Dis., Monog.Suppl.No. 1.
Lehman, H. C. (1953). 'Age and Achievement'. Princeton University Press.
Likert, R. and Hayes, S. P., Jr. (1957) (Editors) 'Some Applications of Behavioural Research'. U.N.E.S.C.O.—printed in Basle.
Mackworth, N. H. (1950). 'Researches on the Measurement of Human Performance'. Medical Research Council, Special Report Series No. 268, H.M.S.O., London.
Musgrove, J. and Petherbridge, P. (1957). Architects J., **126**, 368-374.
Myers, C. S. (1929). 'Industrial Psychology'. (1st Edn.) Oxford University Press.
Myers, C. S. (1941). Occup. Pschol., **15**, 26-34.
Smith, May (1943). 'An Introduction to Industrial Psychology'. (1st Edn.) Cassell & Co., London.
Viteles, M. S. (1932). 'Industrial Psychology'. Norton & Co., Inc., New York.
Urwich, L. and Brech, E. F. L. (1949). 'The Making of Modern Management'. (Vol. 3). Management Publications Trust, London.

Article VI
Anderson, C. C. (1958). 'Function Fluctuation'. Brit.J.Psychol.Monog. Supp.No. 30, Cambridge University Press.
Editorial Comment (1952). Nature, Lond., **170**, 941-943.
'The Fleck Report' (1957). Command Papers No. 338, H.M.S.O., London.
Haire, M. (1950). Harvard Bus.Rev., **28**, 42-51
Halsbury, Earl of (1958). (Synopsis) Nature, Lond., **181**, 95-96.
Myers, C. S. (1941). Occup.Psychol., **15**, 26-34.
Scott Blair, G. W. and Coppen, F. M. V. (1940). Brit.J.Psychol., **31**, 61-79.
Stein, M. I. (1957). *Paper* 3 in Symposium. 'The Direction of Research Establishments'. H.M.S.O., London.
van Lennep, D. J. (1957). *Paper* 4 in Symposium. 'The Direction of Research Establishments'. H.M.S.O., London.

Article VII
Anstey, E. (1950). Occup.Psychol., **24**, 200-229.
Blakeslee, A. F. and Salmon, T. N. (1935). Proc.Nat.Acad.Sci.U.S., **21**, 84-90.
Cavanagh, P. (1955). Occup.Psychol., **29**, 43-57.
Girardot, N. V., Peryam, D. R., and Shapiro, R. (1952). Food Technol., **6**, 140-143.
Guilford, J. P. (1954). 'Psychometric Methods'. (2nd Edn.) McGraw-Hill Book Co. Inc., New York.
Harrison, S. (1952). Proc. 6th Annual Convention Amer.Soc.Qual. Control, 121-128.
Hiscocks, E. S. (1956). 'Laboratory Administration'. Macmillan & Co. Ltd., London.
Hiscock, W. G. (1938). Occup.Psychol., **12**, 178-186.
Hopkins, J. W. (1946). Can.J.Res., F **24**, 203-214.
King, F. B. (1937). Food Res., **2**, 207-220.
Likert, R. and Hayes, S. P., Jr. (1957). 'Some Applications of Behavioural Research'. U.N.E.S.C.O. Printed in Basle.
Pickford, R. W. (1957). Brit.J.Physiol.Optics, **14**, 2-26.
Rubenstein, A. H. (1955). Reprint of Lecture to Royal Swedish Academy of Engineering Sciences.
Rubenstein, A. H. (1957, a). Harvard Bus.Rev., **35**, 95-104.
Rubenstein, A. H. (1957, b). I.R.E. Trans. on Eng. Management, **4**, 72-78.
Shaycoft, M. F. and Altman, J. W. (1955). 'The Standardization of a Test for Selecting Research Personnel'. (Mimeographed). Amer.Inst.for Res., Pittsburgh, Pa.
Taylor, H. C. and Russell, J. T. (1939). J.appl.Psychol., **13**, 565-578.
Weschler, I. R. and Brown, P. (1953). 'Evaluating Research and Development'. Institute of Industrial Relations, University of California, Los Angeles.

ADDITIONAL REFERENCES

Broadbent, D. E. (1958). 'Perception and Communication'. Pergamon Press, New York and London.
Welford, A. T. (1958). 'Ageing and Human Skill'. Oxford University Press.
Gross, C. and Hudson, L. (1958). Nature, Lond., **182**, 787.

The Postgraduate Research Student

The small number of postgraduate research students in technical institutions was deplored by Sir Harry Melville, K.C.B., F.R.S., Secretary of the Department of Scientific and Industrial Research, during the course of his address at the Annual General Meeting of the Association of Technical Institutions, on February 27, 1959.

'The D.S.I.R. Research Studentship is an award which until a few years ago went under the more prosaic title of "D.S.I.R. maintenance allowance". These awards are intended to provide a training in methods of research for young persons holding good honours degrees or acceptable alternative qualifications. This year we hope to make nearly 800 new awards of this sort. The total number current after October next is likely to be about 1,800. In each of the next few years we are likely to increase the number of new awards we make annually by about 10 per cent to reflect the growing output of scientists and technologists.

'When we first started making these awards soon after D.S.I.R. was set up during the first World War, a number of the older technical colleges came to us for this form of help. I was surprised to learn that, although in 1922 we awarded only 156 Research Studentships in all, the number we awarded for tenure in technical colleges was greater than the

number awarded in 1956. In fact, in 1922 the technical colleges took up nearly 10 per cent of our awards, a figure which dropped to about 1 per cent during the 1930s, but which last year I am glad to see rose to nearly 7 per cent.

'It would be idle to deny that the attractions of the universities for the academically brilliant youngster are very strong, and that as a consequence a large proportion of all students suited to postgraduate research is likely always to come from the universities, and also to wish to receive its postgraduate training there. But I think other factors may be at work aggravating this tendency, for too many of the better research students seek their postgraduate training in the universities rather than elsewhere. Perhaps the universities have an attraction which other institutions are only slowly acquiring. Perhaps also the Ph.D. degree, which the university can offer its internal students, provides an attraction which is distorting the distribution of research students in ways that are not in the nation's interest. In some occupations the Ph.D. may have a cash value, and also in the minds of many young people the title of "Doctor" may make some appeal to a very natural streak of human vanity. Other establishments specializing in certain branches of technology and science (for example many technological institutions, the research associations, and D.S.I.R.'s own Stations) can offer a valuable research training but no doctorate as a hall-mark of success in this training (except to the London graduate able to work for his Ph.D. externally).

It remains to be seen whether the newly created Hives research qualification of "Membership of the College of Technologists" will provide an award as popular as the Ph.D.

'The Postgraduate Training Grants Committee of our Research Council includes amongst its members Dr. Venables, the Principal of the Birmingham College of Advanced Technology. But even before Dr. Venables was invited to join this Committee as its expert on the affairs of technical institutions, I can assure you (for as a former university professor, I was at one time the Chairman of a D.S.I.R. forerunner of the present Committee) that D.S.I.R. has always treated applications from technical colleges every bit as sympathetically as it does those from any university. What has often disappointed us has been the small number of students of research calibre who have chosen technical institutions for their training and whom you have been able to recommend to us.

'Therefore we feel that the distribution of our awards could be improved, and the obligation on us to seek ways of doing this has become stronger now that in England and Wales we have almost a monopoly for giving postgraduate awards in science and technology from public funds. 1956 was the last year in which the Ministry of Education and the local education authorities in England and Wales, as well as D.S.I.R., made these awards, and now, with an increased number at our disposal, we do so virtually alone. This rationalization has produced a number of advantages, and from what I hear as I move about outside the Department the new arrangements are on the whole well liked. But I do appeal to the technical institutions to make every endeavour to attract research students of a calibre that qualifies them to take up the many awards we are now in a position to offer for your use.

'I should like to take this opportunity to remind you that we do not insist upon a candidate for our research studentship holding a good honours degree. There are alternative qualifications in which we accept sufficiently good performances in place of a degree (though for the present we have decided it might be invidious and embarrassing to formulate the acceptable alternatives and levels in each of these precisely enough for us to publish a list!) However, we have decided to accept the new Diploma in Technology for our Studentships, and I hope that the staff of technical institutions will help us to make this fact widely known.

'In 1957 we awarded for the first time a D.S.I.R. Studentship of a new sort—the so-called Advanced Course Studentship—which is intended to maintain students taking postgraduate courses of instruction other than in methods of research. In the universities this award enables students to take courses for master's degrees, postgraduate diplomas and the like, but so far very few of the technical institutions have taken advantage of the new scheme. Dr. Venables is Chairman of the Sub-Committee which is looking after our new award, and this slow response must be a matter of concern to him. Perhaps again the lack of a well-known hall-mark for students who have successfully completed a postgraduate course at a technical institution is one of the contributory difficulties.

'While I am speaking of studentships I should like the opportunity to mention briefly that we are now trying to encourage young science graduates and engineers to spend at least one year of their postgraduate training abroad. Our objects in doing this, beyond providing postgraduate training, are to mix promising British postgraduate students with those of other countries; to enable them to work in overseas laboratories; and also to help them benefit more generally as human beings from the interest and stimulus of study abroad. We have also recently announced that D.S.I.R. will administer in this country a scheme of science studentships and fellowships for N.A.T.O., which will encourage international exchanges; and there is on the stocks a Commonwealth Scholarship scheme, of which you are likely to hear more in the future.'

Mathematics and Biological Research

(*Concluded from page* 129)

Finney, D. J. (1956). The statistician and the planning of field experiments. J.R.statist.Soc., A, **119**, 1-17.

Fisher, R. A. (1946). Statistical Methods for Research Workers. Oliver and Boyd Ltd., Edinburgh. (10th Edn.).

Fisher, R. A. (1955). Statistical methods and scientific induction. J.R. statist.Soc., B, **17**, 69-78.

Girshick, M. A. (1953). Book Review. J.Amer.Statist.Ass., **48**, 646.

Goodeve, C. (1948). Operational research. Nature, **161**, 377-384.

Grundy, P. M., Healy, M. J. R. and Rees, D. H. (1956). Economic choice of the amount of experimentation. J.R.statist.Soc., B, **18**, 32-55.

Heyerdahl, T. (1950). The Kon-Tiki Expedition (Translated by F. H. Lyon). George Allen and Unwin Ltd., London.

Hill, Bradford A. Discussion to Finney (1956), 19-20.

Hill, Bradford A. (1947). Statistics in the Medical Curriculum. Brit.med. J., 366-368.

Kelvin, Lord (1891). Popular Lectures and Addresses. Vol. 3. The Constitution of Matter. Macmillan & Co. Ltd., London.

Kempthorne, O., Bancroft, T. A., Gowen, J. W., Lush, J. L. (1954). Statistics and Mathematics in Biology. Iowa State College Press, Ames, Iowa.

Kendal, M. G. (1958). Research in Statistics. J.R.statist.Soc., A, **121**, 196-216.

McKendrick, A. G. and Pai, M. K. (1911). The rate of multiplication of micro-organisms: a mathematical study. Proc.roy.Soc.Edinb., **31**, 649-655.

Pearce, S. C. Discussion to Finney (1956), 18-19.

Pearson, E. S. (1955). Statistical concepts in their relation to reality. J.R.statist.Soc., B, **17**, 204-207.

Powell, E. O. (1958). An outline of the pattern of bacterial generation times. J.gen.Microbiol., **18**, 382-417.

Russell, B. (1948). Human Knowledge. Allen and Unwin Ltd., London.

Smith, C. A. B. (1954). Biomathematics. The Principles of Mathematics for Students of Biological Science. Charles Griffin & Co. Ltd., London.

Snedecor, G. W. (1950). The statistical part of the scientific method. Ann.N.Y.Acad.Sci., **52**, 792-799.

Stacy, R. W., Williams, D. T., Worden, R. E., McMorris, R. O. (1955). Essentials of Biological and Medical Physics. McGraw-Hill Book Co. Ltd., New York.

Thompson, D'Arcy W. (1948). On Growth and Form. Cambridge University Press. (New Edn.).

Tukey, J. W. Causation, Regression and Path Analysis. In Kempthorne *et al* (1954), 35-66.

Von Mises, R. (1957). Probability, Statistics and Truth. George Allen and Unwin, London. (2nd revised English Edn.).

Waddington, C. H. (1951). Operational research. Anim.Breed.Abstr., **19**, 409-415.

Wiener, N. (1948). Cybernetics. John Wiley and Sons, Inc., New York.

Wilk, M. B. and Kempthorne, O. (1955). Fixed, mixed and random models. J.Amer.Statist.Ass., **50**, 1144-1167.

Wold, H. (1956). Causal inference from observational data, a review of ends and means. J.R.statist.Soc., A, **119**, 28-60.

Yates, F. (1935). Some examples of biased sampling. Ann.Eugen., **6**, 202-213.

Yates, F. (1946). The place of statistics in agricultural research. Agric. Progr., **21**, 40-50.

Yates, F. (1949). Agriculture, sampling and operational research. Proc. Inst.Int.Statist., 1-8.

Yates, F. (1952). Principles governing the amount of experimentation in developmental work. Nature, **170**, 138-140.

Yates, F., Boyd, D. A. and Pettit, G. H. N. (1942). Influence of changes in level of feeding on milk production. J.agric.Sci., **32**, 428-456.

A SIMPLE DEVICE FOR DISPENSING LIQUIDS

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IF a polythene wash bottle is tilted to a high angle during use, the flow ceases when the contents of the delivery tube have been discharged. If the delivery tube is replaced by a bulb pipette suitably modified, reproducible deliveries of a known volume can be obtained.

Pipettes of 1, 2, and 5 ml. capacity have been used in 250 ml. bottles, and 5 ml. and 10 ml. pipettes in 500 ml. bottles. Polythene ampoules in which concentrated standard solutions are supplied can be used as reservoirs for 1 ml. and 2 ml. pipettes; the neck of the ampoule should be warmed and splayed slightly. Attempts to deliver, e.g. 20 ml. from a pipette inside a glass reservoir with an external pressure source have not been very successful, the flow tending to begin prematurely.

This paper is based mainly on experience with 5 ml. pipettes in 250 ml. bottles, but the notes on construction and use are of general application. It is likely that the standard deviation of the volume delivered is similar for all sizes.

Construction (Fig. 1)

Although other forms are usable, the preferred type of reservoir (supplied by Townson & Mercer, Ltd.) has an inner polythene sealing ring and an outer screwcap. The device will work with any pipette but not all are equally good. Space in the reservoir is wasted unless the lower orifice of the pipette comes near the bottom (Fig. 2) and this requires an adequate length between the tip and the graduation mark of the pipette selected. The diameter of the jet tube of the pipette should preferably be similar to that of the delivery tube which it replaces, but an oversize tube can be passed through the sealing ring if the latter is warmed, and a tube which is too narrow can be thickened locally by a few turns of adhesive tape, preferably polythene.

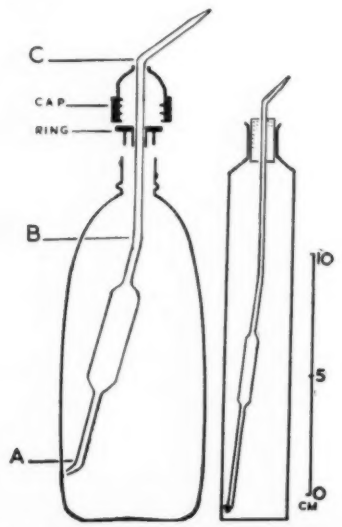


Fig. 1. Devices to deliver 5 ml. and 1 ml., showing construction.

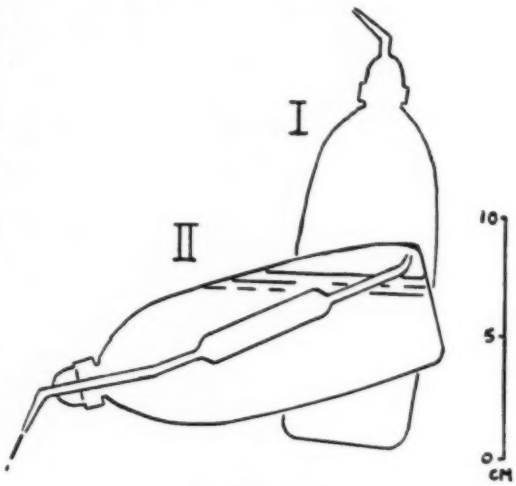


Fig. 2. Device in use.

The glass-working can be done in a few minutes with a micro-burner and the preferred order of operations is as follows:

1. Before cutting the pipette form the bend at A.
2. Constrict the tube somewhat at the graduation mark.
3. Cut off the stem at the mark.
4. Form bend B, being guided by size and shape of the reservoir to be used. B is adjusted later after trial assembly if necessary, so that the lower orifice comes near the wall of the bottle.
5. Form bend C. It is usually advisable to slip the sealing ring over the pipette first.
6. The jet of the pipette may be left unchanged, or constricted for increased precision, or the tip may be cut off for increased speed. This point is further discussed below.

Operation

Grasp the reservoir so that controlled pressure can be applied with the fingers. Holding the device so that the

nozzle points upwards (Fig. 2, I), squeeze gently until the pipette is full to the tip. Surface tension will assist in maintaining this condition. Then tilt the device (Fig. 2, II) by rotating the wrist. The pipette will then empty without any marked increase of hand pressure, and hard squeezing is certainly to be avoided if a number of deliveries are to be made in sequence; it tends to fatigue the hand and impair consistent action.

Factors Affecting Operation

Within the obvious limits of over-full and nearly empty, the liquid level in the reservoir does not affect ease and accuracy of operation. No trouble from air-bubbles in the pipette has been experienced.

As with other forms of pipette, the size of the jet orifice affects operating speed and precision. Experiments were made with a *standard jet* (Fig. 3, I), i.e. that of a grade B pipette unaltered, and with several modifications. Cutting off the tip to form a *wide jet* gave, as expected, a rough and rapid device which could be operated in five or six seconds. Conversely a *constricted jet* made by brief heating of the tip gave significantly increased precision but increased time of operation. With these jets a 'spraying effect' was noted, i.e. the ejection of a few minute droplets during filling, and also a 'wetting effect', an occasional escape of liquid on to the outside of the tube when the pipette was full. Spraying cannot be of consequence in most applications, but wetting must tend to reduce precision. The *rounded jet* (Fig. 3, II) reduced spraying but did not eliminate wetting or improve precision.

The *extended jet* (Fig. 3, III: filled to the capillary, not to the extremity) eliminated both effects but is somewhat more difficult both to construct and to use than are the other forms and for general purposes is not preferable to them. It is suggested that further work with jets of this or similar form might produce an instrument of increased precision. Further constriction of the lower orifice is another subject for possible experiment.

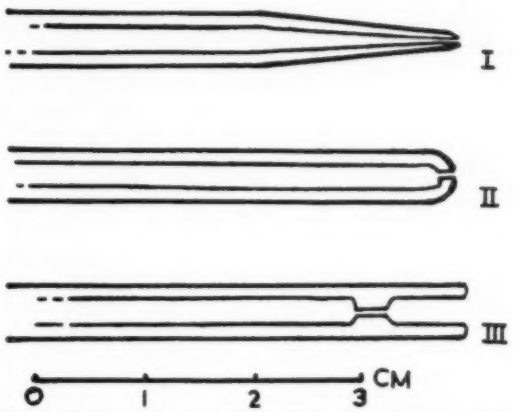


Fig. 3. Forms of jet. I, standard; II, rounded; III, extended.

The table shows weights of water at c. 18°C. delivered in the manner described by the device with several forms of jet, and comparative results for an ordinary Grade B pipette (the identical one used, after modification, for the tests with standard, constricted and rounded jets), a Daffert pipette[1, 2] and a tilt pipette[3] (not actually supplied by A. Gallenkamp & Co., Ltd.). All instruments were cleaned with chromic acid shortly before use. The ordinary pipette was operated according to the instructions of Vogel[4]. The Daffert and tilt pipettes were used with the arbitrary, but standardized draining times stated in the table, the tip touching the receiving vessel during the last few seconds. Two high deliveries (6·2, 6·1 ml.) by the tilt pipette have been excluded because further trials have shown that the operator can observe the failure to zero which these imply, and correct it by rocking the instrument.

The times of operation recorded are the mean time for a cycle of filling and emptying, based on the total time for 10 to 12 operations. These figures have some comparative value, though they might be reduced to

Delivery of Water by Various Instruments
(nominally 5 ml. in each case)

	(i) *Time of operation* sec.	(ii) *Drainage time** sec.	(iii) *Mean wt. delivered ± standard deviation* g.	(iv) *No. of operations*
1. Ordinary bulb pipette	58·5	15	4·9654 ± 0·0040	11
2. Daffert pipette	32	10	4·9782 ± 0·0031	12
3. Tilt pipette**	26·5	5	5·613 ± 0·066	15
4. New device, standard jet	15·3	—	5·046 ± 0·036	21
5. New device, constricted jet	22·2	—	5·057 ± 0·020	12
6. New device, rounded jet	35·8	—	5·010 ± 0·023	10
7. New device, extended jet	22·7	—	5·120 ± 0·019	12

* Included in (i)

**Two deliveries > 6·0ml. excluded for reason given in text

varying degrees by practice or by reduction of draining time.

At the time of testing, the device was not in routine use by the operator and the results are thought not to overestimate the performance to be expected in normal practice. The instrument was not wiped during the tests, i.e. any errors arising through the wetting effect were not eliminated.

The mean volume delivered by the device, which is a 'blow out' instrument, was at first some 1·7 per cent greater than that of the original pipette. It so happened that the work done on the jet in bringing it to the rounded form reduced the volume a little and brought the mean well within grade A tolerance. If desired, deliberate adjustment could be made by removing a little glass at the lower orifice or by heating the pipette locally to cause contraction.

Variation in the volume delivered is of greater interest. Precision with the standard jet is more than adequate for many applications and can be improved by constricting the orifice somewhat if the time of operation (for the 5 ml. size) is less than about 20 seconds. (The orifice of the rounded jet tested was smaller than necessary.) The instrument does not, however, compete with an ordinary pipette or a clean Daffert pipette if stoichiometric precision is desired.

With the constricted jet the standard deviation, equal to two-thirds of the Grade B tolerance limit, implies that the random error (as distinct from the systematic error) associated with the use of this device is similar to that obtaining when one uses a number of 5 ml. pipettes impartially, instead of adhering to a single pipette for a particular purpose.

The error distribution of the 55 trials referred to in the table is shown in Fig. 4. A departure from the normal function is not established at the 5 per cent probability level but there are suggestions of it. There is an apparent maximum in the region of minus 0·5 standard deviation, but this is of little practical importance. There is also an apparent tendency towards high positive errors. This was not unexpected but the evidence for it is not great. Only two positive errors greater than two standard deviations were recorded, viz. 2·42 *s* with constricted jet, 2·30 *s* with extended jet. Over-deliveries of this frequency and magnitude would not be important in the applications envisaged for the device.

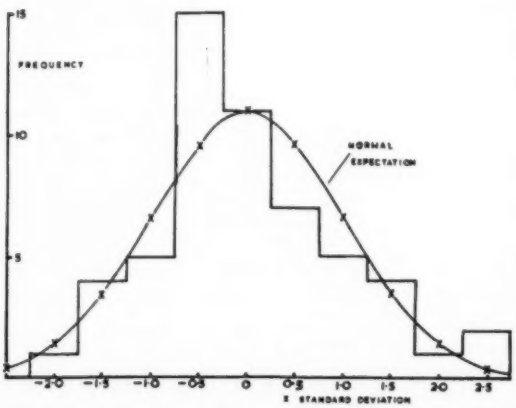


Fig. 4. Error distribution of 55 deliveries.

Applications and Appraisal

Generally speaking, liquids usable in polythene wash bottles can be dispensed from this device. As well as aqueous reagents, alcoholic solutions are satisfactory, but fluids of high vapour pressure such as ether or concentrated ammonia solutions are not suitable. Accuracy may depend on the viscosity and surface tension of the liquid and tests should be made where necessary. Whether it can be used with inflammable, toxic or corrosive substances will depend on circumstances; it has been used quite successfully over a long period to deliver a colour-developing reagent containing some 40 per cent of sulphuric acid by volume.

The reservoir does not store a large volume, but contains enough for 40 to 50 deliveries or more. There is no need to flush the pipette or to reject the first delivery, and the reagent is used economically. The glass part, being largely shielded, is protected from dirt and damage. Removal of the pipette for cleaning is infrequent and the sealing ring need not be taken off the pipette during this process. As an experiment the apparatus was knocked off the bench; it was picked up ready for immediate use. The absence of stopcocks and associated grease, ground joints, rubber connections and gravity feed arrangements removes a number of possible troubles. The blow-out action ensures that no liquid remains in the tip to deposit solid on standing. The device is inexpensive and takes up little space, making it suitable for use in quantity. Moreover it can be made up quickly from easily available components at need. It is very well adapted to use away from the ordinary bench, e.g. in the fume cupboard or outside the laboratory.

The method of use will not perhaps be immediately apparent to the uninstructed and the author has refrained from describing it as an 'automatic pipette', but considers that most people possessing an aptitude for ordinary analytical manipulations could obtain results similar to those reported.

REFERENCES

1. British Standard 1132:1952.
2. A. Gallenkamp & Co. Ltd., 12th Edition Catalogue Vol. 1, (1951) p. 481, item a—1804.
3. A. Gallenkamp & Co. Ltd. ibid. item a—1809
4. Vogel, A. I. (1951). 'Quantitative Inorganic Analysis', 2nd Edition.

APPARATUS AND DEVICES

It is evident from letters received that the Apparatus and Devices Section of *Laboratory Practice* arouses considerable interest. We should like to point out that we are at all times pleased to receive from readers notes, however short or simple, for inclusion in this section.

A SENSITIVE FLUORIMETER FOR MICRO-DETERMINATIONS

by C. C. F. Payne and W. J. Perkins, M.(Brit.) IRE, A.M.I.E.E.

National Institute for Medical Research, Mill Hill, London, N.W.7

THE measurement of fluorescence by photo-electric methods is well known but the measurement of micro quantities necessitates a large degree of amplification (Wokes and Slaughter, 1949; Isbell, 1949; Lowry, 1948). This may be done by applying the output of the photo-electric cell to a D.C. amplifier or by using a photomultiplier. For relatively low gain the D.C. amplifier is quite suitable but where a high gain is required, the photomultiplier is cheaper and simpler.

The instrument to be described was designed to measure the fluorescence of small samples of riboflavin in concentrations of the order of 0·1-1μmg/ml. It was therefore anticipated that the maximum possible sensitivity would be required and an E.M.I. photomultiplier type 6097 was chosen. As all measurements were to be made on a comparative basis, with frequent reference to standards, the long term stability was relatively unimportant, but the short term stability had to be such that variations were below the smallest changes being measured.

Instability is mainly due to the light source, power supply and the photomultiplier itself. Instability due to the first two causes can be reduced if a balanced system is used, with two photomultipliers connected to a common galvanometer and having a common light source. The photomultiplier instability takes the form of random fluctuations (Rodda, 1953) which are a function of the mean current and at low levels of fluorescence may be the most serious error. As this error is not reduced with a balanced system a single photomultiplier is used with a stabilized power supply and light source.

When no light falls on a photomultiplier there is a small current termed the 'dark current'. When the sample cell contains the solvent alone, a residual amount of light, termed the 'optical blank', causes a small additional current. To allow the use of a sensitive galvanometer in the photomultiplier circuit, this current can be backed off electrically. Any fluctuations of this blank current cannot be backed off however and thus form a limit to the available sensitivity, because similar changes of current due to the fluorescence cannot be detected. Reduction of the optical blank is therefore important. It is due to the following causes:

1. Scattered and reflected light which is transmitted through the secondary filters.
2. Fluorescence of the sample cell and any secondary filters and lenses.
3. Fluorescence of the reagent solution used.

The first is reduced by placing the photomultiplier in a plane normal to the incident light, limiting any possible reflection paths between light source and photomultiplier and by blackening all surfaces. The main reflecting path is in the cell holder so that particular care must be taken in its design. A further reduction can be made by using optical cells and blackening the unused surfaces including the edges of the inlet and outlet surfaces.

The second can be reduced by selection of the optical components and by simplifying the secondary optical system.

The third cause can be reduced by sufficiently purifying the solvent to yield low fluorescent extracts (Sebrell and Harris, 1954).

The initial use of the instrument described was with riboflavin which has a maximum fluorescence at 5650A and is excited over a number of wavelengths from 4800A down to 2250A. Riboflavin is destroyed rapidly by ultra-violet radiation so that the primary filter system chosen was a Corning 3389 and 5113 combination which covered the required pass band, eliminating the ultra violet and the radiation above 4800A which gave no

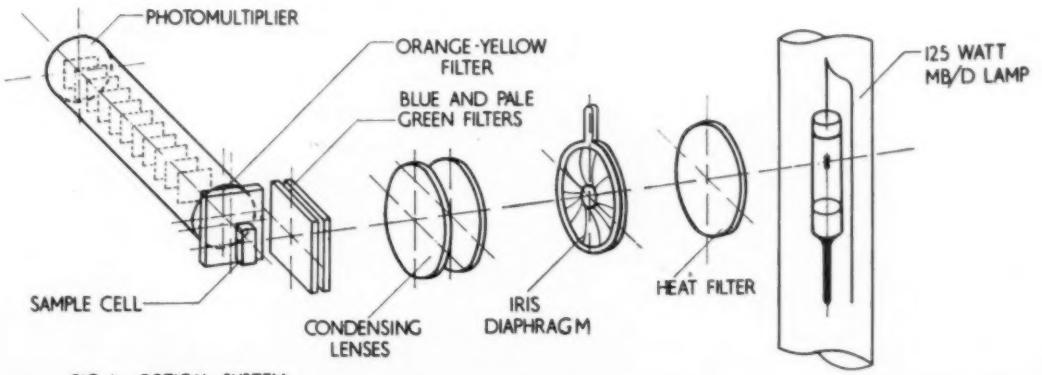


FIG. 1 OPTICAL SYSTEM

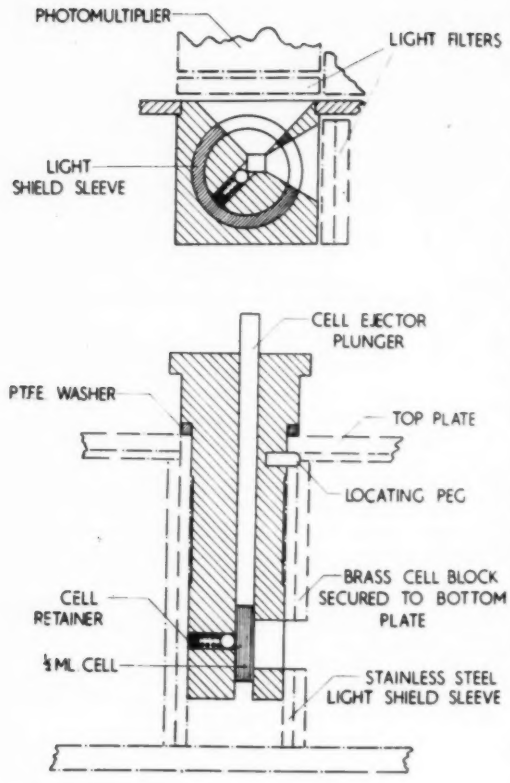


FIG 2 CELL HOLDER AND LIGHT TRAP

increase in fluorescence and could only increase the optical blank. This arrangement selected the 4358A line from the mercury lamp source. The 5113 filter was itself fluorescent and was placed on the lamp side of the combination. The secondary filter was a Corning 3486 with a low cut off at 5200A and this combination, which was the one chosen by Lowry (1948) was found to be the most suitable.

For riboflavin the exciting and fluorescent wavelengths are reasonably separate and interference filters were not considered necessary. A parallel light path was therefore not required in the secondary and it was possible to dispense with a lens system, enabling the photocathode to be placed close to the sample cell, separated only by the secondary filter. The large surface area collected a high proportion of the available fluorescence and avoided the losses and fluorescence of a collimating lens.

The optical layout is shown in Fig. 1. The cell is approximately 20 cm. from the light source and two biconvex lenses produce a reduced image of the 2 c.m. source in the sample cell. A Siemens 125 watt MBD mercury vapour lamp with a restricted arc was found to be the most suitable source and requires no stabilization. Convection cooling of the lamp housing is sufficient and a Chance ON20 heat filter reduces the heat reaching the sample holder. An iris diaphragm controls the illumination reaching the cell and thus acts as a sensitivity control.

The internal dimensions of the optical cells are 25 mm. × 5 mm. × 5 mm. with a volume of 0·625 ml. The cell holder illustrated in Fig. 2 is made of brass and arranged to take the cell from below. A plunger pushes the cell approximately one third out of its normal position where a light spring clip secures it from slipping and it can then be removed without handling the sides. This

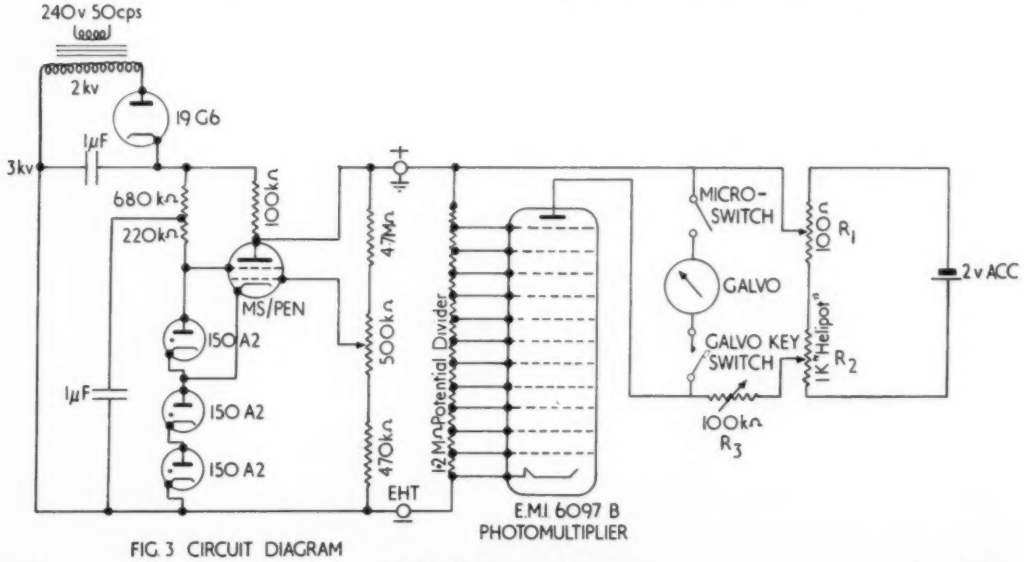


FIG 3 CIRCUIT DIAGRAM

holder and an outer stainless steel sleeve, having apertures registering with those of the holder, rotate together into the operating position where the holder is prevented from being withdrawn. When rotated 180° the photomultiplier is blanked off and the holder can be removed. A micro-switch disconnects the galvanometer unless the holder is turned fully into position and protects the galvanometer when the backing off circuit is being used.

The circuit of the instrument is shown in Fig. 3. A 2000 volt stabilized supply provides the EHT with the positive earthed to hold the galvanometer at earth potential. The galvanometer is a Pye Scalamp with a sensitivity of 20 cm/μA. A backing off circuit supplied by a 2-volt accumulator enables any standing current to be backed off by R_1, a Helipot R_2 measures changes of fluorescence by adjusting for a null reading of the galvanometer, thus allowing the full sensitivity of the galvanometer to be used. R_3 is a swamp resistor to prevent shorting of the signal through the backing off circuit.

The optical blank with distilled water or sulphuric acid was reduced to the equivalent of a 1 ml. sample of riboflavin at a concentration of 0·2 μmg/ml. With an EHT supply of 1900 volts the meter deflection was approximately 1 to 1·25 μA with a dark current of 0·1 μA. Riboflavin samples gave the following readings:

1·0 μmg/ml.—2·5 μA ± 1 per cent fluctuation

0·1 μmg/ml.—0·75 μA ± 3 per cent fluctuation

If the optical blank were reduced still further the same sensitivity and precision could be obtained with lower concentrations, as the overall gain could be increased by a factor of at least 25 with this type of photomultiplier.

A second instrument using the same principles was constructed for the determination of intermediary metabolites (Greengard, 1956).

The difference in the fluorescence properties of oxidized and reduced nucleotides was used for the estimation of intermediary metabolites at levels of 2×10^{-10} mole.

In this case a Hilger 'Spekker' absorptiometer was used to provide the source of illumination and a convenient base for mounting the rest of the instrument. The cell holder and photocell unit were replaced by single cell holder with input and output filters and photomultiplier, as previously described. The backing off photocell of the Spekker was not used and the fluorescence was measured by a direct reading of the galvanometer.

The photomultiplier has proved quite suitable for the measurement of very low levels of fluorescence but should be selected for minimum fluctuations of mean current. Care should also be taken to reduce the optical blank.

ACKNOWLEDGMENT.—*The authors would like to acknowledge the assistance of Mr. C. W. Couling, who designed the cell holder.*

REFERENCES

Greengard, P. (1956). Nature, **178**, 632.
Isbell, R. A. C. (1949). Analyst, **74**, 618.
Lowry, O. H. (1948). J.Biol.Chem., **173**, 677.
Rodda, S. (1953). 'Photo-Electric Multipliers', London: Macdonald & Co.
Sebrell, W. H. and Harris, R. S. (1954). 'The Vitamins'. Academic Press Inc.
Wokes, F. and Slaughter, G. (1949). Analyst, **74**, 624.

Space Research

The first meeting of the newly formed National Committee on Space Research was held on March 4 in the rooms of the Royal Society. This Committee has been set up to co-ordinate British research activities in upper atmosphere research, and to co-operate with the Committee on Space Research (COSPAR), which was set up by the International Council of Scientific Unions (ICSU) to arrange for international collaboration on scientific experiments conducted in space.

The United Kingdom delegate to COSPAR is Mr. M. O. Robins of University College, London. Other United Kingdom members of COSPAR who represent various international scientific unions are:

Prof. H. S. W. Massey, F.R.S. International Union of Pure and Applied Physics.

Prof. A. C. B. Lovell, F.R.S. International Union of Scientific Radio.

Dr. P. Alexander. International Union of Biological Sciences.

Prof. Massey is also a member of the Executive Committee of COSPAR.

The British National Committee on Space Research is constituted as follows:

Chairman: Prof. H. S. W. Massey, F.R.S.

Royal Society: Sir Lindor Brown, Sec.R.S.
Prof. W. V. D. Hodge, Sec.R.S.
Dr. H. G. Thornton, For.Sec.R.S.
Prof. D. R. Bates, F.R.S.
Sir Edward Bullard, F.R.S.
Prof. W. R. Hawthorne, F.R.S.
Prof. F. Hoyle, F.R.S.
Prof. A. C. B. Lovell, F.R.S.
Mr. J. A. Ratcliffe, F.R.S.
Dr. L. R. Shepherd.

Dr. R.v.d.R. Woolley, F.R.S., Astronomer Royal.
Dr. H. A. Brück, Astronomer Royal for Scotland.
Sir Graham Sutton, F.R.S., Director-General of the Meteorological Office.
Mr. M. O. Robins, United Kingdom delegate to COSPAR.
Dr. A. H. Cook (Royal Astronomical Society).
Prof. W. J. G. Beynon (Physical Society).
Sir Arnold Hall, F.R.S. (Royal Aeronautical Society).
Dr. R. L. Smith-Rose (Department of Scientific and Industrial Research).
Mr. P. D. Greenall (Department of Scientific and Industrial Research).
Sir Owen Wansbrough-Jones (Ministry of Supply).
Sir George Gardner (Ministry of Supply).
Dr. R. C. Cockburn (Ministry of Supply).
Dr. A. W. Lines (Ministry of Supply).
Prof. P. A. Sheppard (Royal Meteorological Society).
Air Commodore W. K. Stewart (Physiological Society).
Mr. R. N. Quirk (Office of the Lord President of the Council).
Mr. I. Maddock (Atomic Energy Authority).
Dr. J. S. McPetrie (Institution of Electrical Engineers).

INTERNATIONAL SYMPOSIUM ON MICROCHEMISTRY

PART II

Organized by the Midlands Section and the Microchemistry Group on behalf of the Society for Analytical Chemistry, and held under the patronage of the International Union of Pure and Applied Chemistry, the International Symposium on Microchemistry took place at Birmingham University from August 20 to 27, 1958. Summaries of many of the lectures are given and those requiring the whole of the papers will be interested to know that the lectures and discussions are to be published in full by Pergamon Press Ltd. as the Proceedings of the Symposium.

No. 33. Microbiological Assay of Antibiotics, Vitamins and Amino-acids, by D. C. M. Adamson and J. S. Simpson.—The importance of the microbiological assay laboratory in the research, development, production and analytical control of antibiotics, vitamins, and amino-acids, as well as other substances, is stressed. A critical account is given of the literature and of methods used in the author's laboratories. For antibiotics, established techniques can generally be adapted to the assay of a particular antibiotic. A review of dilution methods, turbidimetric, titrimetric and gravimetric methods, and diffusion methods is given and factors affecting their performance are discussed. A comparison is made of tube and plate methods for vitamins and amino-acids and the conditions for successful assay discussed.

No. 34. The Use of Fungi for Determining Trace Metals in Biological Materials, by D. J. D. Nicholas.—Lower levels of trace metals than those previously reported may be determined in biological materials by the *Aspergillus niger* method, the (M) strain giving the best results. Gallium, cobalt and vanadium may be omitted from the culture solution and deionized water may be used. The bioassay of molybdenum and manganese in soils is profoundly affected by the initial pH of the culture solution; copper and zinc are affected to a smaller extent. Tropical soils have lower limiting values of trace metals than temperate soils. Results are reported of assays of trace metals in various plant fractions and in enzyme preparations, and the advantages and disadvantages of the method are discussed.

No. 35. The Microbiological Assay of Protein Quality, by G. D. Rosen.—Microbiological assay could be regarded as a compromise between the physico-chemical assessment of protein, which does not necessarily reflect biological availability, and the practical feeding investigation which is too costly and slow for routine use. It would seem particularly suited to rapid screening of large numbers of protein samples. The applications and merits of bacterial and protozoal methods are reviewed, and the latter, using *T. pyriformis*, appear at present preferable. Prospects and possible limitations are discussed.

No. 36. Survey of Methods useful in Functional Group Determination of Organic Substances, by Stig Veibel.—Spot tests, although sometimes useful in detecting functional groups, do not usually permit identification of individual organic compounds. Methods are described for the identification by determining the equivalent weight by titration, either directly or after conversion to a suitable derivative. Such methods are discussed in detail for the hydroxyl group, sulphides, carbonyl compounds, carboxylic acids and sulphonic acids. Radio-chemical methods may also be used, and three such methods are described.

No. 37. Organic Functional Group Analysis, particularly referred to the Alkoxyly Determination, by W. I. Stephen.—Recent developments in the methods for determining alkoxyl are discussed under the separate headings of apparatus, wash liquids, absorbing solutions and alternative procedures. The British Standard apparatus is compared with others, particularly from Swedish laboratories. There is general agreement that thiosulphate wash liquids are detrimental. An alternative to the classical absorbing solution is found in Gran's modification of the Willstätter and Utzinger procedure, which is selective for methoxyl, but also permits simultaneous determination of methoxyl and ethoxyl. A colorimetric method, and sub-micro determination, are also discussed.

No. 38. The Teaching of Organic Microchemistry, by M. K. Zacherl.—With the goal in view that training in microanalysis should give the analyst complete confidence in his techniques and in his mastery of them, various methods of instruction in organic microanalysis are examined. Pregl's method, whereby a small number of well-qualified students were taught solely by laboratory demonstrations and instruction, is suited to the production of able specialists on heads of microanalytical laboratories. Where more students must be trained, and where their background may not be so certain, other schemes of instruction must be employed, and a number of these are described.

No. 39. Trace Element Losses during Mineralization of Organic Material, a Radiochemical Investigation, by J. Pijck, J. Hoste and J. Gillis.—A survey is given of the available literature of the mineralization process of organic material preceding the determination of trace elements. In our experimental research two particular processes were investigated, namely dry ashing at temperatures of respectively 400°, 500°, 700° and 900°C., and wet destruction with a mixture of nitric, perchloric and sulphuric acid.

The following elements were used in the form of radiotracers of high specific activity: V, Cr, Mn, Fe, Co, Cu, Zn, As, Mo, Ag, Sb, Au, Hg and Pb.

From our results it appears that considerable losses occurred for many elements when dry ashing is used, even if the oven temperature does not exceed 400°C.

Quantitative recovery was obtained by wet destruction with the investigated mixture of acids, though a reflux-condensor was necessary for the elements Fe, As, Sb, Au and Hg.

No. 40. Reliability of Microchemical Weighing, by G. F. Hodsman.—The roles of precision and accuracy in analysis are discussed, and sources of error in microchemical weighings are reviewed and ways of mitigating their influence suggested. These are considered under the headings of environmental errors, such as the effects of changes of temperature and humidity; instrumental errors, such as the accuracy

of shape and position of knife-edges and planes; and weighing techniques, including acclimatization of objects. The assessment of weighing errors is discussed, and the precautions necessary for absolute weighings are considered.

No. 41. Errors in Weighing not Inherent in the Balance, by Mary Corner.—The types of error caused by external factors are examined and their magnitude assessed where possible. The effects of vibration, and ways of minimizing them, are described. Changes in temperature, pressure and humidity are considered from the point of view of their effect on the performance of the balance and on surface moisture on glass and porcelain objects. The characteristics of suitable materials for tares, and treatment of glass and porcelain objects prior to weighing, are discussed.

No. 42. Some Observations on Organic Analysis, by J. Haslam.—An outline is given of the methods in use in the author's laboratories for the micro-determination of elements, ash, acid and ester values, hydroxyl and alkoxyl, molecular weight, density and refractive index. Progress is assessed and possible applications examined of work in various fields of organic analysis. These include ultramicro methods, the volumetric determination of carbon and hydrogen, electrolytic procedures, gas chromatography, the extension of qualitative tests for quantitative work, and high voltage electrophoresis.

No. 43. Some Problems in Industrial Inorganic Microanalysis, by C. Whalley.—The applications of microchemical methods to some inorganic analytical problems in the paint, pigment and varnish industries are described. A scheme has been developed to enable relatively semi-skilled operators to analyse even complicated pigment mixtures, and it has been extended to permit semi-quantitative analysis of certain mixtures. Methods are described for the determination of trace metal constituents in, for example, media, pigments and water. A special technique was evolved for the analysis of gas samples of 0·2 to 0·5 ml. in volume. Examples of problems concerning the examination of blemishes in paint films are described.

No. 44. Microdetermination of Molecular Hydrogen by Galvanic Analysis, by P. Hersch.—Traces of hydrogen in a carrier gas, down to fractional volumes per million, are recorded continuously using the oxygen-sensitive galvanic element previously described by the author. The gas stream, after receiving a constant level of oxygen, e.g. by electrolysis, is led over platinum-plated silica wool at 500°C. Despite the high dilution, combustion can be made quantitative. It causes a drop of the galvanic current output proportional to the concentration of hydrogen. Very slow rates of corrosion of metals in acids can thus be measured almost instantly. The method is recommended, *inter alia*, for determining hydrogen thermally evolved from metals, or passing diffusion barriers.

No. 45. Determination of Physical Constants, by Martha Sobotka.—A programme for teaching micro methods of physical constant determination has been devised on the basis of the author's experience in the U.S.A. and in Europe. The development of these methods has received considerable attention in the U.S.A. Details of the methods, including principles and practice, are presented for the determination of vapour pressure curves, surface tension and density, with a critical evaluation of published methods and descriptions of the author's modifications.

No. 46. Micro-heterometric Analysis and the Micro-heterometric Study of Chemical Reactions, by M. Bobtelsky.—Heterometry deals with the quantitative study of chemical reactions in suspensions. Generally a heterometric titration curve presents many 'critical points', or breaks, which provide quantitative information on the step reactions occurring in the system. The relation of heterometry to other physical analytical methods is discussed. Heterometric micro-analytical methods for quick determination, without previous separations, of traces (0·1 per cent) of most of the metals in presence of more than 99 per cent polyvalent foreign metals are reviewed. The pH dependency, accuracy and advantages of the method are discussed. Heterometry is furthermore a unique and excellent tool for the study on microscale of complicated reactions in suspensions. Examples of such studies are presented.

No. 47. Millicoulometric Methods of Analysis, by C. N. Reilley.—The design of optimum conditions for coulometric analysis at constant potential or at constant current requires recognition and manipulation of thermodynamic and kinetic parameters. The former are best studied by plots of the free energy level of the true titrant versus some solution parameter; such plots summarize in an easily digestible picture the outcome of the various competing equilibria. Kinetic factors are best studied from polarization curves. Several procedures have been developed to shorten the time required for an analysis. A wide variety of titration reactions is available and the scope of coulometry is fast approaching that of volumetric analysis.

No. 48. Glass Electrodes Responsive to Sodium Ions, by G. Mattock.—The possibility of developing alkali metal ion response in glass electrodes has recently been investigated by several workers. Preliminary studies have been made here on two glasses, one designated BH 17, and another devised by Eisenman *et al.* The former was made to improve on the difficult working features of the Eisenman glass. Their response properties in sodium solutions, potassium solutions and pH buffers are described. The response to sodium is nearly theoretical in the range $10^{-2}M$ to $10^{-5}M$; the responses to potassium and pH are considerably less than theoretical. Their potentialities for sodium determinations are discussed.

No. 49. Compulsory Microanalytical Training, by C. J. van Nieuwenburg.—Training in qualitative analysis at University level is often given in two stages: a preparatory course and a later introduction to modern analytical procedures. In the latter, micro methods must be taught. In the former their neatness, rapidity and elegance provide the best means of teaching. Quantitative analysis may not always be preferably taught on the micro scale. Gravimetric micro methods are, however, gradually replacing macro procedures, and again they are more rapid, more elegant and cheaper. It is better to teach these methods early, and deal later with those cases where macro methods are preferable. Microanalysis is an essential feature of tomorrow's analysis.

No. 50. Analytical Procedures for the Flask Combustion Method, by W. Schöniger.—Conventional methods for the determination of halogens and sulphur in organic compounds are considered to be too long. The flask combustion, in which the sample is wrapped in a piece of ash-free filter paper and burned in a closed oxygen-filled flask containing an appropriate absorbing solution, is much more rapid. Details are given of the combustion, and suitable methods of finish for the determination of fluorine, chlorine, bromine, iodine, sulphur, phosphorus and carbon-14 in organic compounds are described.

No. 51. The Rapid Determination of Small Amounts of Carbon and Sulphur in Inorganic and Organic Substances by means of Conductivity Measurements, by H. Malissa.—The change in conductivity resulting from the passage of the combustion gases through suitable solutions is employed for determining carbon and sulphur in organic and inorganic

compounds. The procedure is very sensitive and extremely rapid. An additional advantage is that no weighings other than the sample weight are needed, and consequently the precautions and time losses accompanying the widely used Pregl determinations of carbon are no longer necessary. The use of a tube without any filling is a further advantage.

No. 52. The Present State of Complexometry in Czechoslovakia, by R. Pribil.—Work has been concentrated on the investigation of new indicators, new screening reagents and new methods of isolation finishing with suitable complexometric determinations. A description is given of the uses and limitations of a series of indicators derived from the phthalein and sulphon-phthalein dyes. Screening agents, particularly for use in acid medium, are discussed, and a rapid method of analysis of certain fusible alloys has been developed. Extraction processes have been used to permit complexometric determination with unfavourable concentration ratios of cations.

No. 53. New Reagents in Complexometric Analysis, by T. S. West.—Two main approaches are possible in developing this method of analysis: (*a*) to synthesize new chelating agents which are in some way more selective than EDTA, (*b*) to evolve better and more selective indicators for visual titration.

New chelating agents synthesized by the speaker and his co-workers included among others, 1, 2-diaminocyclopentane-tetra acetic acid (CPDTA), 1:2 diaminocycloheptane tetra acetic acid (CHDTA) and 2:3 butylenediamine tetra acetic acid (BDTA). Nearly all were considerably more powerful than EDTA in their action.

Solochrome Black 6B (C.I. No. 201) was recommended as indicator for magnesium; Omega Chrome Red B (C.I. No. 652) for nickel in acid solution at pH 4·6-11; Fast Sulphon Black F (C.I. No. 306) was specific in its action with copper; Acid Alizarin Black SN (C.I. No. 337) is recommended for Ca in the presence of Mg.

Alizarin-complexone—a new chelating indicator synthesized from alizarin is particularly excellent for Pb and Zn in acid solution and may also be used for Co, Ca and In at the same low pH. The cerous complex of this reagent gives a specific colour reaction with fluoride, which is interfered with seriously only by oxalate. This reaction was used for the determination of traces of fluoride.

No. 54. British Contributions to the Progress of Microchemistry, by R. Belcher.—Microchemical methods were first practised generally in the United Kingdom about 1925-26, although there is evidence of isolated cases of occasional use in the last century. The Microchemical Club was formed in 1934, and this later became the Microchemistry Group of the Society for Analytical Chemistry. This organization in both its forms has made some useful contributions to the progress of microchemistry in Britain. Microchemical methods have been applied widely, particularly in the field of metallurgical analysis, and some valuable techniques have been developed. Among the latest work, methods for the analysis of organic compounds which require only 30-50 μg sample are of interest, and should be of value in such fields as biochemistry where only small amounts may be isolated.

No. 55. The Determination of Nitrates by 'Dead-Stop' Titrimetry, by A. F. Williams and J. Brooks.—The principle of 'dead-stop' titrimetry has been applied to the determination of nitrate ions by titration with ferrous ammonium sulphate solution in strong sulphuric acid medium. The method is simple and is applicable to low concentrations of nitrate ions where existing potentiometric and bimetallic electrode systems appear to be inapplicable. It has also been applied to the determination of readily hydrolyzable nitric esters such as introcellulose and introglycerine, and is applicable to the determination of nitrates in the presence of excess chloride ions.

No. 56. Titrimetric Finish of Chromatographic Spots on Paper, by Alice Lacourt.—The direct titrimetric determination of five elements on paper chromatographic spots is described. The reproducibility is governed by end-point discrimination and reproducibility of the blank determinations, and is quite satisfactory down to the microgram level. The technique offers a simple aid to quantitative chromatographic investigations in the absence of a spectrophotometer.

No. 57. The Microanalytical Determination of Carbon and Hydrogen, by W. Schöniger.—In the last few decades many important modifications to the Pregl method, as well as completely new methods, have been described. These are discussed in three groups: modifications in combustion conditions, in removal of oxides of nitrogen and in the final determination of water and carbon dioxide.

No. 58. CHEL 242 as a New Complexing Agent in Titration and in Masking, by K. L. Cheng.—In general, CHEL 242 reacts with metals similarly to EDTA, but appears to react faster than EDTA with aluminium and zirconium. These metals may be titrated at room temperature. Aluminium and titanium in mixture can be determined in two titrations. The use of CHEL 242 in strongly alkaline media offers a definite advantage in that metals such as iron, zirconium and hafnium are not hydrolyzed at room temperature. It forms weaker complexes with a few metals than EDTA; in certain cases it could with advantage be used as a masking agent. It will be interesting to correlate its structure and behaviour towards metals with those of EDTA when its structural formula is disclosed.

No. 59. Some New Possibilities in EDTA Titrations Using Methyl Thymol Blue as Indicator, by E. Körös.—By using methyl thymol blue as indicator, the scope of complexometric titrations has been increased. Ferrous iron can be titrated directly with EDTA in solutions of pH 4·5 to 6·0. For the complete analysis of mixtures of iron and alkaline earths, 1, 2 diamine cyclohexane tetra acetic acid must be used as titrant, since the iron-EDTA complex is not stable in the alkaline conditions needed for the titration of the alkaline earths. Similarly, manganese can be titrated directly in solutions of pH 6 to 6·5 and this titration has been used in the analysis of ferrites. Other useful applications include the determination of copper and zinc in brasses and bronzes and of bismuth and cadmium in low temperature alloys.

No. 60. Final Meeting: Prof. M. Stacey, F.R.S.

Recent British Standards

Aqueous Solutions of Sulphuric Acid

The B.S.I. has just published B.S.753:1959 (price 15s.), a new edition of British Standard, which was first issued in 1937. The 50 pages of tables based on the International Critical Tables give density in g./ml. of the aqueous solution, mass in grammes of H_2SO_4 in 100 grammes of aqueous solution, and mass in grammes of H_2SO_4 in 1 litre of aqueous solution. The numerical data remain unchanged for the temperature range 10°C. to 40°C. and the density range 1·000 to 1·846.

The accompanying text has been revised to take account of the fact that the 1936 version of B.S. 718 'Density hydrometers' has been replaced by B.S. 718:1953 'Density and specific gravity hydrometers'.

Copies of this Standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London W.1.

PROBLEMS OF QUANTITATIVE PAPER CHROMATOGRAPHY

THE fourteenth national meeting of the Association of Clinical Biochemists was held at the Royal College of Surgeons, London, on Saturday, October 4, 1958, and took the form of a joint meeting with the Association of Clinical Pathologists. The morning session was devoted to a Symposium on Problems of Quantitative Paper Chromatography. Prof. C. E. Dent presided. The following papers were read.

Introduction and some theoretical aspects. R. Consden (Canadian Red Cross Memorial Hospital). Quantitative paper chromatography was faced with problems not only common to all other ultramicro methods but also to those peculiar to the technique itself. Paper contained many contaminants, inorganic and organic, which could interfere and sometimes required elaborate pretreatment to remove such impurities. The mixture to be analysed had to be free of substances which would interfere with separation; conditions of chromatography and temperature of drying were other factors to consider. In quantitative work the separated zones were either eluted from the paper and then estimated or determined on the paper by scanning. The second method was not used so extensively as in paper electrophoresis but was preferable for many purposes if the inherent difficulties could be overcome. Two dimensional separations were then dealt with briefly, referring particularly to the aminoacids. Relative positions of some could be changed in the second direction and so a wider area of the paper could be utilized. The nature of the side chains had important effects on relative solubility in solvents, such as ionization or de-ionization and hydrogen bonding. By judicious choice of the two solvent systems, these effects could be utilized for obtaining good separations.

Chromatography of androgens, oestrogens and progesterone. R. V. Short (School of Veterinary Medicine, Cambridge). The problem of steroid determinations in the urine of domestic animals is complicated by qualitative differences in the metabolites excreted by some species, and by the presence of interfering substances in the urine extracts. In addition, the major excretory pathway for some steroid metabolites may be via the gastrointestinal tract. These difficulties have emphasized the need for a simple technique that is capable of measuring the active steroids in the peripheral blood of any animal. Such a method has already been described for the determination of progesterone in peripheral blood (Short, R. V. (1958). J. Endocrinol., **16,** 415). With a few minor modifications this method can be adapted for the simultaneous determination of androstenedione, testosterone oestrone, oestradiol-17-beta, oestriol, and probably corticoesterone and hydrocortisone (Short, R. V. (1958). Mem. Soc.Endocrinol. in press). The basic steps in the modified procedure are as follows: (1) Titration of the plasma to pH 10·0 with N NaOH, (2) Extraction with ether, (3) Ether extract evaporated to dryness, partitioned between light petroleum and methanol, (4) Application of the methanolic extract to a paper chromatogram. Paper chromatography is carried out in the Bush system appropriate for the steroids to be estimated. The steroids are eluted from the paper and measured in the spectrophotometer. The Kober reaction is used for the oestrogens, and the ultra-violet absorption at 240 millimicrons for the alpha-beta-unsaturated androgens and progestogens. Using a microcell attachment, this limits the sensitivity to 0·5-1·0 microgram of steroid. With the application of fluorimetric techniques, it should be possible to achieve a ten to hundred-fold increase in sensitivity. This should permit the determination of these steroids in a small sample of peripheral blood.

Quantitative chromatography of steroids. I. E. Bush (Radcliffe Infirmary, Oxford).

The assessment of disordered indole metabolism using paper chromatography. M. Sandler (Royal Free Hospital, London.) Assay of biological fluids for indoles by paper chromatographic techniques can only be, at best, roughly quantitative. The reasons given for this included the lability of some of these compounds during desalting procedures, their susceptibility to atmospheric oxidation, certain specific drawbacks of the solvent systems commonly used and the variability of colours obtained with developing reagents. Qualitative studies, using two-dimensional techniques especially are of great value in clinical practice, however. Diagnostic patterns may be obtained in the carcinoid syndrome, Hartnup disease, phenylketonuria, melanogenuria and other disorders.

Quantitative measurement of amino acid paper chromatography. L. Fowden (University College, London). A good separation of the substances to be assayed is the first essential for successful quantitative amino acid chromatography. The importance of choosing the best type of paper and developing solvents for the particular investigation is well understood, but often little attention is paid to the preliminary treatment of the experimental sample prior to its application to the chromatogram. Normally considerably better separations result when salts, soluble carbohydrates and other substances are removed from the samples before analysis. Small cation-exchange resin columns of Zeocarb 215 or 225 or Dowex 50 are generally more useful than electrolytic desalting for this purpose since samples treated in this way contain little other than amino acids whereas the latter method of treatment only removes the salts. The solvent combinations phenol/n-butanol-acetic acid and phenol/collidine-lutidine still remain the most generally useful for amino acid separation. Phenol must be removed from the chromatogram by prolonged drying at temperatures below about 40°C. if substantial losses of amino acids are to be avoided. In this respect more volatile solvent systems possess marked advantages over phenol for then low-temperature drying can be effected much more rapidly. The solvent system n-butanol-ethyl methyl ketone-8·5N ammonia (5:3:2 parts by vol.) used in association with n-butanol-acetic acid has been shown to be particularly useful when protein hydrolysates are to be assayed (Wolfe, M. (1957). Biochem.biophys,Acta, **23,** 186), but it is less useful when free amino acid compositions are required since the spots of glutamine and asparagine overlap those of several of the protein amino acids.

After satisfactory separation has been achieved the amounts of individual amino acids are normally estimated after colour development with ninhydrin. Some methods seek to effect full colour production with ninhydrin while the amino acids are still on the intact chromatogram; colorimetric assays are then made either by scanning with a suitable photoelectric densitometer or by measurement in a spectrophotometer after complete elution of the coloured complex from the spot. It is difficult to obtain complete reproduction of pH, ninhydrin concentration, temperature, etc., over the whole surface of the chromatogram during the colour development stage so that these types of method tend to be somewhat less accurate than alternative procedures in which spots are first located and then removed from the chromatogram before the production of the ninhydrin colour. Am-

monia and other volatile ninhydrin-reactive materials, which would otherwise produce high 'paper blank' readings, can be removed from the paper (Fowden, L. (1951). Biochem.J., **48,** 327), before quantitative colour development is undertaken; each amino acid spot is treated with a measured amount of Moore and Stein's ninhydrin reagent (Moore, S. and Stein, W. H. (1948). J.biol.Chem., **176,** 367), or some simple modification thereof. If the highest level of accuracy is required all colorimetric readings should be related to those obtained from 'standard' amounts of each amino acid run under similar chromatographic conditions.

Careful experimentation can reduce the errors of the paper chromatographic method to about 5-7 per cent of the values obtained.

Serum protein separations on ion exchange cellulose columns. H. P. Tombs, K. B. Cooke, and N. F. Maclagan (Westminster Medical School). A method has been developed for the fractionation of serum proteins into five groups (P, A, B, G, and L in order of elution) on carboxy-methyl cellulose columns (Peterson and Sober (1956). J.Amer.Chem. Soc., **78,** 751). Protein was estimated in the eluant by the u.v. absorption at 280 millimicrons. Carboxy-methyl cellulose was chosen because it was possible to obtain higher flow rates of eluting buffer than with diethyl amino ethyl cellulose, so that a serum required about three hours for examination. Group P contained mainly alpha-l globulins. Albumin was fractionated between groups A and B, but it was shown by re-chromatography that the two forms of albumin were completely interconvertible. They may bear some relationship to the electrophoretically distinguishable isomeric forms of albumin reported recently. Alpha-2 globulins were distributed throughout the elution system. Beta-globulins occurred mainly in group B and gamma globulins in B and G. The areas of the peaks bore a strict quantitative relationship to the amount of protein eluted, and can be used for comparative purposes providing due allowance is made for the different specific absorption of the various components at 280 millimicrons. It seems that resolution into electrophoretically homogeneous components is very unlikely using a single run technique but that re-chromatography of groups obtained in a rough elution system such as this one leads to very high resolution. There is no upper limit to the amount of serum which can be employed.

In the discussion which followed Dr. I. Smith pointed out that English smog, unlike Californian variety, contained reducing substances such as hydrogen sulphide and sulphur dioxide, and so was not necessarily disadvantageous to indole chromatography, which in fact was particularly simple using the technique of Jepson, where neat urine is run without preliminary treatment. He also pointed out that whether quantitative work is necessary depends on the nature of the compounds investigated. In the case of steroids, keto-acids, iodothyronines, for example, the clinical significance is in the quantitative variation from the normal; in the case of sugars, indoles and aminoacids it is the qualitative appearance of compounds not normally present, as in galactosuria, phenylketonuria or argentaffinoma which is clinically important and experience so far suggests that in none of these three cases would quantitative information be of extra value in therapy.

Miscellaneous papers were read at the afternoon session. Dr. G. K. McGowan was in the chair.

Uropepsinogen excretion in patients with gastric lesions. J. Schrager (Wigan). The uropepsinogen excretion was estimated in 232 healthy adults, 188 patients with active duodenal ulcer, 66 patients with gastric ulcer and 90 patients with gastric carcinoma. At least three 24 hour specimens of urine were examined in each individual. The available data show that the range of uropepsinogen excretion in healthy adults falls between 36 and 90 micrograms per hour with an average mean output of 70 micrograms per hour (using Armour pepsin as standard). It remained constant within 10 per cent for each person. In many cases the tests were repeated three or four times at monthly intervals without significant change in spite of wide variation of urine volume. Patients with duodenal ulcer had uropepsinogen excretion well above normal with a mean output of 150 micrograms per hour. The excretion in patients with gastric ulcer was lower than that of duodenal ulcer patients, but significantly higher than the controls, with a great variation in output ranging from 35 to 270 micrograms per hour. It is suggested that this is due to the pathological condition of the gastric mucosa. Histological examination of the stomachs of patients who were operated on and whose uropepsinogen had been previously estimated, revealed widespread gastritis and metaplasia. It was possible to correlate the uropepsinogen excretion with the state of the gastric mucosa. The excretion in patients with gastric carcinoma was well below normal and a considerable number excreted no uropepsinogen at all. The mean excretion in this group was 26. It is suggested that uropepsinogen excretion may prove helpful in differentiating between benign and malignant lesions, and may help in the discovery of early malignant changes. The disappearance of uropepsinogen from the urine on repeated examination suggests widespread changes in the mucosa and warrants further examination.

The method used for the *estimation of uropepsinogen* is as follows: *Reagents:*

1. Acetate buffer, pH 4·9 (NaOH 42 g., glacial acetic acid 92 ml., distilled water to 1 litre).
2. Hydrochloric acid, 2 N.
3. Methyl orange, 0·2 per cent aqueous solution.
4. Casein-buffer substrate.

Into a 100 ml. volumetric flask place 0·3 g. of acid free casein. Add 20 ml. of distilled water and exactly 10 ml. of N NaOH. The flask should be rotated gently while the sodium hydroxide is added slowly. After the casein has dissolved, slowly add 12 ml. of N acetic acid and continue to rotate gently the flask without producing froth. Add 10 ml. of a solution containing 1·2 mg. calcium chloride in acetate buffer pH 4·9. Make up to 100 ml. with acetate buffer. This keeps in the refrigerator for one week.

Technique: Collect a 24 hour specimen of urine and immediately on receipt acidify 2 ml. with 0·1 ml. of 2N HCl and store in the refrigerator until the test is performed. The resulting pH should be acid to methyl orange, i.e. pH 3 or less. The acidified urine is incubated in a water bath for one hour. Pepsin activity remains unchanged by further incubation. All reagents used are brought to 37°C. To a test tube add 0·1 ml. activated urine, 0·9 ml. distilled water and 1·0 ml. acetate buffer. Mix thoroughly. Add 0·5 ml. casein substrate, shake the tube quickly and start a stop watch. Place the tube in the 37°C. water bath. Shake the tube slightly every 5-10 seconds. The end-point of the reaction, aggregation of the casein particles, is sharp and can be read with an accuracy of less than five seconds. The end-point should fall between 40 and 80 seconds. Adjust the volume of urine used so as to obtain an endpoint within this range. The volume of urine thus required may vary between 0·05 and 1·0 ml. but in the majority of specimens 0·2 ml. will be found to give the desired readings. Test crystalline pepsin (Armour) at concentrations from 0·4 to 0·1 micrograms per 0·1 ml. of

solution as for urine and prepare a standard curve. Occasionally it may be found necessary to add acetic acid or sodium hydroxide to the acetate buffer until a satisfactory standard curve (ranging from approximately 40 to 80 seconds) is obtained.

An immunochemical analysis of the proteins of normal urine not present in blood. G. Grant (Shrewsbury). The immunochemical analysis of normal urine proteins by the agar gel diffusion and immuno-electrophoretic methods was described. Rabbit antisera prepared against normal urine colloids, against normal semen and against the salt precipitated mucoprotein of Tamm and Horsfall respectively were used after absorption with normal serum. About eleven antigenic components not present in normal blood serum were detected in normal urine. Some appear to be specific to the urinary tract; others are common to male urine, female urine and semen and so might be excreted by the urethral glands. In addition traces of prostatic proteins occur in the male. The mucoprotein of Tamm and Horsfall appear to be the principal urine protein not detected in blood. It arises from the upper urinary tract and is a mixture of immunochemically similar proteins of varying electrophoretic mobility. Published methods for the quantitative analysis of urinary mucoproteins measure the carbohydrate content of protein mixtures rather than that of a single protein.

Comparison of protein-bound iodine determinations with radioactive iodine tests in thyroid disease. K. Steinitz (Haifa, Israel). A modification of Barker's incineration method for serum protein-bound iodine was discussed. Incubation was done at 24 ± 0·1°C. for 30 minutes in an ordinary well insulated water bath. Colorimetry was done without the internal standard described by Barker. Using this method on 230 cases gave a normal range from 4 to 8 micrograms per 100 ml. with values under 4 in hypothyroidism and over 8 in nearly all patients with hyperthyroidism; in the latter group values up to 20 were obtained though there was some overlap between 7 and 8. These were compared with four radioactive techniques, namely the two hour and the 24 hour uptake, the eight to 24 hour urinary excretion, and the PBI^{131} after 48 hours. The two hour uptake showed a good correlation in clear cases of hyperfunction, a bad correlation in normal and a worse one in cases with non-toxic goitre or other states of iodine avidity. About three-quarters of this group could not be diagnosed correctly. The 24 hour uptake, today considered as the least valuable of all I^{131} tests, gave in 39 of 40 cases of non-toxic goitre or iodine avidity an abnormal increase, together with normal serum protein-bound iodine by the chemical method. The eight to 24 hour urinary excretion of I^{131} gave results comparable with the two hour uptake; that is, relatively good results for clear hyperfunction, and a false classification of about 70 per cent of euthyroid cases of iodine avidity. The 48 hour PBI^{131} though known to be influenced by the rate of turnover of the organic iodine in the thyroid, proved to be superior to the other three radioactive methods. Its correlation with serum PBI is much better and even in the bad group with iodine avidity the error is less than 20 per cent.

The estimation of oxalic acid in urine and other biological material. A. Hodgkinson and P. M. Zarembski (M.R.C. Unit, Leeds). The existing methods for the estimation of oxalic acid in urine were reviewed and a new procedure based on the method of Powers and Levatin (J.biol.Chem., **154**, 207, 1944) was described. The principle of the method is as follows: Urine is acidified with hydrochloric acid and half-saturated with ammonium sulphate. The gelatinous precipitate formed after standing is removed by filtration and the filtrate is extracted continuously with peroxide-free ether. The extracted oxalic acid is precipitated as the calcium salt and reduced to glycollic acid by boiling with zinc powder and sulphuric acid.

Glycollic acid is estimated colorimetrically by heating with chromotropic acid. Recovery of oxalic acid from aqueous solution and from urine was found to be 98 ± 2 per cent. The procedure can be applied, with suitable modification, to the determination of oxalic acid in foodstuffs and renal stones. The daily excretion of oxalic acid by 39 normal adults on a balanced diet containing 60 to 80 mg. of oxalic acid daily ranged from 9·0 to 23·8 mg. The urinary excretion of oxalic acid was found to vary directly with the intake of oxalic acid and inversely with the intake of calcium. Excretion also varied directly with the purine content of the diet and a close correlation was found between the urinary excretion of oxalic acid and uric acid.

The authors wish to thank Dr. J. Dawson and Mrs. K. Rodgers, Department of Biochemistry, University of Leeds, for their advice in the initial stages of this investigation.

The inheritance of an idiopathic low plasma pseudocholinesterase level. H. Lehmann, Valerie Patston and Elizabeth Ryan (Bart's). The short term action of the muscle relaxant suxamethonium is due to its rapid destruction by pseudocholinesterase. If the plasma level of this enzyme is low, the response to this drug is prolonged. The usual causes of this are liver disease and to a lesser extent general debility. Very occasionally patients were observed with an abnormally long response to suxamethonium where the low level was without obvious aetiology. Investigation of the families of such people led to the discovery of healthy persons with abnormally low pseudocholinesterase levels. It was suggested that the likelihood of finding these people by chance would be well below one in 1,000. In an attempt to get information on the mode of inheritance it was assumed that a very low pseudocholinesterase level up to 35 units (Warburg) represented the homozygous condition for an abnormal gene, and that the high normal level above 90 units indicated the normal homozygote. It remained to be seen whether within the intermediate range 36-90 units the heterozygote could be differentiated from the two homozygotes. Kalow and Staron have described an atypical pseudocholinesterase and have examined the mode of its inheritance but it is not yet certain whether the homozygotes for the gene determining the abnormal enzyme correspond with the abnormal homozygotes of the present study. Earlier findings seemed to be consistent with the assumption that the inheritance of a recessive gene might be responsible for an idiopathic level less than 36 units. Allott and Thompson however described a family where the enzyme levels in three children and one sister of a male propositus were roughly halfway between those in the propositus and his wife, who had normal levels. They suggested that a single gene might find expression in the phenotype. The normal plasma pseudocholinesterase level has a range of 61-120 units. A level within the 36-60 range in otherwise normal persons should therefore indicate the heterozygous state. Random finding of such people is unusual, but amongst 72 relatives of 14 propositi 16 of them were discovered (22 per cent). The 72 relatives were composed of the propositi's children and grandchildren their siblings with their children and grandchildren, and their parents with their siblings. Forty-three of the remaining 56 relatives showed values within the normal 61-120 range. This range might well be subdivided into one greater than 90 units definitely indicating the normal homozygous state, and another 61-90 units within which both normal homozygotes

TABLE I

People with plasma pseudocholinesterase less than 36 units	*Relatives*		*Plasma pseudocholinesterase (Warburg (units))*			
	Group	*Number*	*Below 36*	*36—90*	*61—90*	*Over 90*
17	Parents & Children	34	1	12	21	0
13	Siblings	26	11	3	9	3
8	Spouses	8	0	0	4	4

and heterozygotes could be found. The following states could then be presumed:

Less than 36 units—abnormal homozygotes; 36-60 units—heterozygotes, 61-90 units—heterozygotes and normal homozygotes; over 90 units—normal homozygotes. If this assumption is correct no parents of children of persons with an enzyme level less than 36 units should show a level greater than 90 units, but some should be found among their siblings, the number depending on whether their parents were all heterozygotes or included some abnormal homozygotes. (See Table I). By studying the families of 14 propositi data were obtained which appeared to fulfil these conditions and which might allow the conclusion that the inheritance of the plasma pseudocholinesterase level is determined by two allelic genes, neither of which shows dominance.

A blood serum test for leukaemia and neoplasia. D. S. Murray and J. M. Daly (Group Laboratory, Kingston-on-Thames). The authors have developed a theory of the mechanism involved in leukaemia which postulates a flaw in DNA production in the bone marrow through a histidine or imidazole compound. This would have the double action of removing zinc ions which normally inhibit DNAse and of acting directly as an accelerator of DNAse activity. A search for this substance revealed a compound, probably a conjugate since it can be detected only after hydrolysis in a hot alkaline solution (0·5 ml. serum boiled for 30 seconds in 1·0 ml. 20 per cent sodium carbonate), and which appears to be present in excess in neoplastic cases. It is measured by adding 2·5 ml. of the diazo reagent used in the Van den Bergh reaction and reading with an Ilford Filter 404 in the colorimeter against a blank prepared at the same time. No false negatives have been obtained and only two proven false positives out of 246 tests. The test appears very reliable as a diagnostic aid. The normal range is very narrow and distinct from the abnormal. Highest 'neoplastic' readings are found in myelogenous leukaemia; in lymphatic leukaemia these are not so high. In carcinoma the figure is always above normal but very variable although all carcinomas give a positive reading. It is possible that some other forms of malignancy do not give positive results but sufficient cases have not yet been tested. The test is upset by raised urea figures; and false positives are probably related to liver damage. The test may prove to have a value in assessing the effect of different forms of treatment of the neoplastic disease.

Symposium on Biomechanics

In view of the growing importance of the applications of mechanical engineering in the fields of medicine and surgery the Institution of Mechanical Engineers is to hold a Symposium on April 17 which will be devoted to the discussions of papers on various aspects of biomechanics.

Four papers will be presented and discussed as follows:

'The Importance of Biomechanics as a Service to Man, illustrated by a Discussion of Problems in Metallic Osteosynthesis', by J. M. Zarek, B.Sc., Ph.D., A.M.I.Mech.E.; 'The Lubrication of Animal Joints', by John Charnley, M.B., Ch.B., F.R.C.S., with appendixes as follows: 'Derivation of an Expression for Friction Coefficient', by F. J. Edwards, M.Sc., A.M.I.Mech.E., 'Calculation of the Shear Rate in the Hip Joint Lubricant', by R. I. Tanner, B.Sc., M.S., G.I.Mech.E., 'The Lubricating Properties of Synovial Fluid,' by R. I. Tanner, B.Sc., M.S., G.I.Mech.E., and F. J. Edwards, M.Sc., A.M.I.Mech.E., 'Some Tests on "Fluon" as a Material for Artificial Animal Joints', by R. I. Tanner, B.Sc., M.S., G.I.Mech.E.; and 'The Provision of Workable Substitutes for Missing or Defective Limbs', by D. S. McKenzie, M.B., Ch.B. and Brigadier N. A. M. Swettenham, O.B.E., B.A., A.M.I.Mech.R.

A film will be shown during the Symposium on 'Late Results of Four Massive Internal Prostheses', by A. C. Bingold, F.R.C.S. and W. G. France.

Science Laboratory Technicians

The City and Guilds of London Institute and the Institute of Science Technology announce that they have taken important steps to rationalize their examinations and qualifications for science laboratory technicians.

Hitherto, both Institutes have held examinations for science laboratory technicians, but in future there will be only one series of examinations, held by the City and Guilds of London Institute on behalf of both Institutes. The conduct of the examinations and their further evolution will be under the guidance of a joint advisory committee of both Institutes and the certificates awarded to successful candidates will bear the heading: 'The City and Guilds of London Institute in conjunction with the Institute of Science Technology'.

Transitional regulations have been agreed to ensure that no student at present preparing for the examinations of the Institute of Science Technology suffers because of the new arrangements. The arrangements for the award of the Fellowship of the Institute of Science Technology remain as hitherto.

The great importance of adequate numbers of suitably trained technicians in the nation's science laboratories has been stressed in many quarters and there is no doubt that the work of both Institutes has played a notable part in promoting the wider appreciation of the importance of the science laboratory technician and of his (or her) special requirements for education and training. The existence hitherto of two broadly similar schemes of examination and qualification has unfortunately dissipated effort. But the rationalization that has now been achieved will undoubtedly be an important step forward, particularly in promoting the successful establishment of courses of study in technical colleges, universities and elsewhere which will permit the technician to be given the comprehensive theoretical and practical training that is so essential if he is to attain the highest standards in his calling and be competent to furnish the professional scientist with the assistance he requires.

News from the British Association of Chemists

RADIOISOTOPES IN INDUSTRY

Members of the London Section of the B.A.C. recently heard a most interesting lecture on this subject by Mr. G. B. Cook, of the Atomic Energy Research Establishment, Harwell.

Mr. Cook commenced by referring to the present very large and rapidly expanding number of applications of radioactive isotopes in industry. He proposed to give a survey of their use in industry generally but to quote examples as far as possible of a chemical interest. He grouped the uses into four categories:

1. As a source of ionizing radiation.
2. The use of radioactive isotopes as a source of penetrating radiation.
3. As physical tracers, where the chemical identity of the radioactive material and the components being traced are not important.
4. As chemical tracers in which this identity is invoked.

Use of Ionizing Sources

The lecturer said that the build-up of static electricity in industry is often a serious problem. He instanced the serious fire hazard arising from sparks produced by its discharge; handling difficulties caused by mutual repulsion of non-conducting charged fibres; dust attracted to such fibres which can be very difficult to remove, and powders sticking to surfaces so that they would not pour properly. A well-known instance in the textile industry is 'fog marking'. This could be overcome by the exposure of a radioactive source over the cloth remaining in the loom at the end of the working day.

Use of Penetrating Radiation

Mr. Cook said that many applications of isotopes in industry depend on the power of radiations to penetrate matter. The majority of methods used in routine manufacturing and engineering processes fall in this class. Perhaps the simplest of them is that of 'gamma radiography', which is essentially the x-ray examination of articles using the penetrating gamma-rays of radioisotopes to replace the penetrating x-rays. This substitution eliminated the need for power supplies and only a simple lead container, which is quite easily transported, is required to contain the radioactive source. Some examples of techniques and various types of sources were described in connection with welding, gauging of levels, densities and thicknesses. Thickness gauges are the most commonly used radioactive instruments in industry and their application ranges from thin paper to sheet metal.

X-Ray Fluorescent Spectroscopy

Mr. Cook referred to the work now being done on the uses of radiation which were of particular interest to chemists, such as the development of X-ray fluorescent spectroscopy as a method of analysis. The possibility of replacing the X-ray tube by a radioactive source is being investigated in connection with this.

Physical Tracers

Examples considered were the operation of a sponge iron furnace, investigations into the functioning of plant for the underground gasification of coal, and in the field of refinery technology.

Chemical Tracers

Applications where the chemical identity of the radioactive atom and the system are important were considered. Some of the best examples are found in chemical analysis. Radioactive techniques have been of great assistance in this field, perhaps the most widely used application in the analysis is radioactivation analysis. Mr. Cook also discussed the analytical technique known as the isotope dilution method.

In conclusion he said that the Isotope Division at Harwell operates an advisory and experimental service to help apply these methods and is always prepared to discuss radioactive techniques for suitable problems.

A full report of the lecture is being published in *The British Chemist*.

Life Members

The undermentioned have been elected Life Members of the Association:

Gay, A. D. Age 57. Elected Member 1928. (London.)

Phillips, S. B. Age 64. Elected Member 1920. (Birmingham and W.M.)

Obituary

It is with regret that we record the decease of the following members:

Bowker, F. C. Aged 78. El. M. 1918/19. El. Life Member 1951. (Northern.)

Davies, W. T. G. Aged. 65 El. M. 1927. (Bristol and S.W.)

Read, F. W. Aged 75. El. M. 1919. El. Life Member 1945. (Bristol and S.W.)

Section Programmes

Birmingham and West Midlands

A visit to the West Midlands Gas Board Swan Village Works at West Bromwich has been arranged for the evening of Wednesday, April 15, 1959.

The Section Annual Meeting is to be held at 7 p.m. on Wednesday, May 6, 1959, at the Chamber of Commerce, New Street, Birmingham.

Liverpool

The Annual Meeting of the Section will be held on Wednesday, April 29, 1959, at the Grenville Cafe, Tithebarn Street, Liverpool, at 6.15 p.m.

After the meeting there will be a visit to a local theatre.

London

The Annual Meeting of the Section will be held on Wednesday, May 6, 1959. Details will be circulated to members in due course.

The summer excursion is scheduled for Sunday, June 7, and will be a tour of the Oxford Colleges.

*

Mr. J. L. Hewson of the Chemical Engineering Services Department of I.C.I., gave an interesting lecture entitled 'The Disposal of Effluents of Chemical Works' on Wednesday, February 11, before an audience of about 40 members and friends.

Mr. Hewson stressed the importance of the problem, which had been the subject of legislation for over half a century. He dealt with the various problems of disposal of gaseous, solid and liquid effluents. Liquid effluents presented some of the most difficult problems, and, with the aid of lantern slides, the lecturer indicated some of the ways of dealing with the problem, stressing the usefulness of holding tanks or lagoons, which helped to even out sudden surges of concentrated industrial effluent, and often invoked the use of microbiological decomposition to remove sludges. Effluent entering fresh water rivers had to pass stringent tests to comply with regulations, and dangerous chemicals such as cyanides and sulphides must be completely removed. The use of old mines or pits for dumping waste might lead to complications if there was any seepage into underground fresh water courses.

Manchester

On Friday, December 12, 1958, members of the Section entertained wives and friends to a supper at the Seymour Hotel, Chorlton. Mr. J. Richman, the Chairman of the Section, was supported by our President, Mr. J. Wilson. The guest of the evening was Mr. H. H. Armstrong, T.D., B.SC., F.R.I.C., Head of the Science Department at Stockport College for Further Education.

An excellent supper was followed by an entertainment given by a 'magician' who would no doubt prove an acquisition to many a research department! The evening was informal, and was greatly enjoyed by nearly 40 members and friends.

All correspondence and enquiries concerning this Association should be addressed to G. R. Langdale, Esq., The British Association of Chemists, Nomination Dept., 14 Harley Street, London, W.1. Tel.: Museum 7021.

Laboratory Note-Book

WOULD you like an interesting and rewarding career in the largest research and development organization in the country, with a great tradition dating back to the beginnings of Government defence research? This is the opening question posed by the Ministry of Supply in a new booklet, An Invitiation to Science Graduates, which has been produced to attract Honours Graduates in Science as they qualify in Universities over the next two or three years.

This is an exceedingly attractive booklet and it contains answers to all the questions that applicants to the service might ask—categories of scientific staff, promotion, retirement pensions, and addresses of most of the establishments giving a broad picture of the range of work which is open to Ministry of Supply scientists. A neat envelope at the end of the booklet contains full details of conditions of service, an application form and an O.H.M.S. envelope in which to despatch it.

Chemical Clerihews

Readers of the current issue of the *M & B Laboratory Bulletin* are invited to try their hand at emulating Mr. Edward Clerihew Bentley.

Many readers must have been introduced to chemistry by way of Dr. Holmyard's elementary textbook—'the old brown Holmyard'—a book which relieved the unbelievable tedium of the Laws of Constant Composition and Multiple Proportions by unexpected references to Harun al Raschid, to buns in the tuck-shop (was it *really* called the 'grubber' at Clifton?) and to the delights of Meccano. It was in this book that we met our first Clerihew, now, of course, a classic:

Sir Humphrey Davy
Abominated gravy.
He lived in the odium
Of having discovered sodium.

Dr. Holmyard attributed this to Mr. Hilaire Belloc but we believe (on the evidence of Mr. G. K. Chesterton) that it was the first ever written by Mr. Edward Clerihew Bentley himself—written, so it is said, when he was a schoolboy, bored and baffled by a long exposition of some dreary electrolytic process.

We have never found any other genuinely chemical clerihews, and competitors are asked, therefore, to fill this gap in scientific literature. Contributions should be on *any three* of the following: Robert Boyle; Bouvealt and Blanc; Cannizaro; Henry Cavendish; Friedel and Crafts; Hell, Volhard and Zelinsky; Peter Griess; Geber (Jabir ibn Hayyan); Victor Grignard; van 't Hoff; E. J. Holmyard; August Kekulé; Martin Henry Klaproth; Lavoisier; May & Baker; Mendeléef; Lothar Meyer; Paracelsus; Joseph Priestley; Sir William Ramsay; Szent-Györgyi; Zerewitinoff.

Entries should be sent to:

The Competition Editor,
M & B Laboratory Bulletin,
Dagenham, Essex.

by June 30, 1959. The usual first prize of five guineas, and consolation prizes, are offered.

Automation in the Bowling Alley

The popular B.B.C. television programme Tonight recently showed how automation is creeping into the American world of sport. Bowling alleys, it seems, are the current craze for Americans of all ages and sizes, but today the small boy who used to earn himself pocket money by setting up the scattered skittles has been ousted from his position by the advent of automation. An arm comes down, sweeps away the remaining upright skittles on to a type of continuous conveyor and from above another intricate set of automated 'hands' sets the requisite number of skittles in place ready for the next onslaught.

Signs of the times indeed.

Transfer of D.S.I.R. Stations

Three D.S.I.R. Stations—all concerned with the preservation, storage, handling or protection of foodstuffs—will be transferred to the Agricultural Research Council on July 1. They are the Ditton Laboratory at Larkfield, Kent, the Low Temperature Research Station at Cambridge, and the Pest Infestation Laboratory at Slough.

The agreement between the Council for Scientific and Industrial Research and the Agricultural Research Council—which has received the approval of the Lord President of the Council (Lord Hailsham)—was made because the two Councils believe that it is in the national interest to bring all Government research on food other than fish under one body. The aim is to make the research more effective.

The staff in the three laboratories, numbering about 200, will be invited to transfer to the service of the Agricultural Research Council. If they accept, they retain their existing pension rights and conditions. They will also remain eligible for consideration for posts in the Civil Service. No redundancy is expected as a result of this transfer.

For those not wishing to transfer to the Agricultural Research Council, the Department of Scientific and Industrial Research will do its utmost to find suitable alternative employment either within its own organization or elsewhere in the Civil Service.

The photograph shows the use of Stelvetite for bench tops.

Stelvetite used for New Laboratory

Stelvetite, a new material combining P.V.C. plastic with sheet steel, has been used by the Electro-Chemical Engineering Co. Ltd., for a number of applications in a new laboratory just completed at their Sheerwater, Woking, factory.

John Summers & Sons Ltd., the Chester steel company, developed and introduced Stelvetite after many years of research. It comprises P.V.C. plastic, bonded by a special process to sheet steel. The combination of the two materials thus provides the strength of steel with the colour, corrosion resistance and other properties of plastic.

The Electro-Chemical Engineering Company Ltd. have used Stelvetite for bench tops, fume ducting and for the casing of an instrument panel.

The properties of Stelvetite make it resistant to acids and alkalis within wide limits and therefore such liquids present little danger to the surface of the material. Stelvetite is also resistant to abrasion, humidity, oils and greases. It has good electrical properties, does not support combustion, withstands considerable heat and can easily be cleaned with detergents.

In the construction of the bench tops which are used for plating tests, Stelvetite was formed round a wood base and P.V.C. filler paste used to finish the corners. For the fume ducting the plastic side was faced internally and the reverse side (electro-zinc coated) was painted. A d.c. control panel containing voltmeter, ammeter, two rheostats and a rotary selector switch, has been made entirely with the new plastic-coated steel.

LABORATORY EQUIPMENT & APPLIANCES

Micro-Projector Model 11

The C & D Micro-Projector Model 11 was originally designed in 1947. Great improvements have since taken place, and our recent addition of a completely new type of condenser system, which collects the maximum light from the 6 volt 48 watt bulb, now makes it possible to project on to the screen with the 1/12 in. (x100) oil immersion objective.

An iris diaphragm is fitted to the condenser system to reduce the very brilliant light when using the low power objectives, and also to help with the dark filter when using as a normal microscope. The dark filter is now permanently fitted to the instrument.

This low priced, well finished instrument is easy to manipulate and most efficient.

(Manufacturers: C & D Scientific Instruments Ltd., 439A London Road, Boxmoor, Herts.)

Automatic distillation apparatus for the petroleum industry.

Automatic Distillation Apparatus

A recent addition to the range of test equipment developed for the petroleum industry is an automatic distillation apparatus made under licence from The British Petroleum Company Limited.

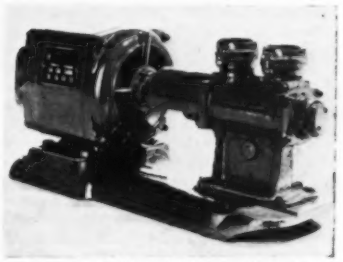
This apparatus is based upon a rapid distillation method for the routine testing of refinery products when the value of a single point on the distillation curve provides sufficient information for day-to-day volatility control. Repeatability is better than by standard methods.

Entirely automatic, the apparatus carries out a distillation in a matter of minutes—an operation which normally takes the best part of an hour.

Its method of operation is briefly as follows: 10 millilitres of the sample to be tested is introduced into a flask by means of a pipette. A thermocouple is inserted into the neck of the flask and the receiver is placed in position. The heater is then switched on (using voltage appropriate to the product) by operating button. When the selected temperature is reached automatic cut-out switches off the heater. The volume of the distillation to the nearest 0·05 ml. is then noted, after allowing half a minute for draining. After each distillation, the residue in the flask is removed by suction. The complete operation takes no longer than 10 minutes, of which less than three minutes is operator's time.

A booklet containing detailed instructions and wiring diagrams is issued with each unit.

(Manufacturers: F. J. Hone & Co. Ltd., 19 Eldon Park, London, S.E.25.)



The new light-weight pumping unit.

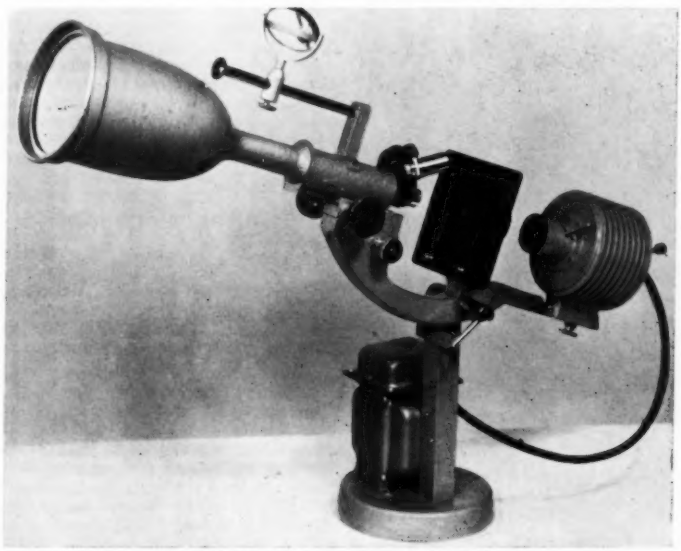
New Process Pumping Set

A new compact light-weight pumping unit, specially designed for food and chemical processing applications, factory and laboratory installations, is also suitable for general pumping duties.

To a Goodyear Size A5 positive displacement pump is coupled a Newman 'Elf' ¾ h.p. ac electric motor mounted on a special light-weight aluminium bedplate casting. The pump, with a normal operating speed of 1,440 r.p.m., delivers five gallons of water per minute. It is completely self-priming and can run with a dry suction for long periods making it ideal for emptying vats and barrels completely. This versatile pumping unit is also capable of handling viscous fluids and fluids which contain suspended solids.

The Goodyear A5 rubber-to-metal type pump has only two moving parts in contact with the liquid, the plate wheel and rotor. The taper roller bearings are grease packed for long life, and high efficiency radial face shaft seals are fitted which do not cause the shaft to wear as they become due for renewal, as with a packed gland.

A special feature of the design is the cast light alloy bedplate, curved over its



The C & D Micro-projector, Model II.

central span for rigidity and ease of cleaning. This has meant a reduction in the weight of the set and has provided an attractive appearance. Provision is made for two lifting handles, one on each side of the unit, using the same bolt holes as for the permanent installations. The pump is driven through a Spencer Moulton 'Jubo' coupling which is adequately protected by a metal guard.

It should be emphasized that this pump set is virtually silent when running on full load and it can be commended for duties where quiet running is an important consideration.

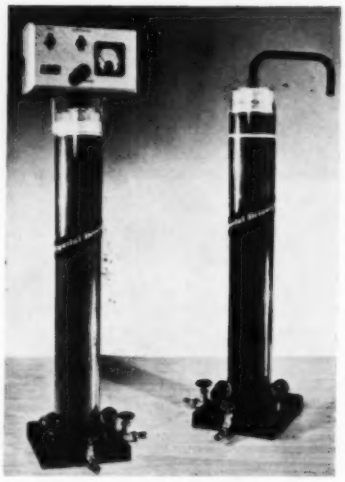
The set with Meehanite pump weighs 46 lb., and the dimensions are 20½ in. long, 7¼ in. wide and 9½ in. high. The set can also be supplied with pumps in bronze, light alloy or stainless steel.
(Manufacturers: Goodyear Pumps Ltd., Camborne, Cornwall.)

Elgastat Major Mark II

The Major Mark II, developed from the Elgastat Major, for the production of deionized water, has the following improvements incorporated:

1. All exposed components are now made from corrosion-resistant plastic. The unit may therefore be used with confidence in corrosive atmospheres.
2. Flow rates: Equilibrium water (4 megohms/cm+) may now be drawn at the rate of up to 10 gallons (45 litres) per hour.
   Distilled quality water (500,000 ohms/cm+) can be drawn at the rate of 20 gallons (90 litres) per hour.
3. Two versions are available:
   Where the requirements are, in the main, for commercial grade distilled water, a capacity and exhaustion indicator is incorporated. (Type B.104).
   For critical applications, a conductivity monitor forms an integral part of the unit, and gives an accurate quality check throughout the exhaustion cycle. (Type B.104/CON).

A standard modification makes it possible to pipe deionized water to any number of draw-off points. In common with all Elgastats, no regeneration in situ is necessary, and the Elgalite Cartridge service applies.
(Manufacturers: Elga Products Ltd., Railway Place, London, S.W.19)



The Elgastat Major Mark II.

New Range of Small Nitrogen Plants

A range of small, compact and completely self-contained plants for the supply of liquid or gaseous nitrogen, has been developed. Five models are available which between them cover capacities from 1·5 to 24 litres of liquid nitrogen per hour or 2 to 30 standard cubic meters (70 to 1000 s. cub. ft.) of gaseous nitrogen per hour.

These plants are designed to produce nitrogen of up to 99·9 per cent purity by the liquefaction and fractional distillation of air. By virtue of their sizes, weights and capacities they are ideal for use in tropical and isolated areas where supplies of nitrogen are not readily available from other sources. Applications include the provision of liquid nitrogen for petroleum gas analysis on remote oil field sites and liquid or gaseous nitrogen for general laboratory, refinery and chemical works usage.

All these nitrogen plants comprise four principal sections which carry out the following functions:

1. Compression of the incoming air.
2. Removal of carbon dioxide.
3. Drying.
4. Condensing and subsequent separation of nitrogen by fractional distillation.

The use of regenerative driers, a caustic soda scrubber, and cross countercurrent heat exchangers, ensure long trouble-free runs. The drying and separation sections are each housed in neat, attractive, stove-enamelled cabinets. Foundations are required for the high pressure multi-stage compressor and caustic soda scrubbing tower but these units can be housed in positions remote from the other two.

The plants are fully instrumented, completely wired up electrically and only require interconnecting pipework and electricity supply cables to be installed by the user.
(Manufacturers: Refinery Equipment & Speciality Co. Ltd., Valley Works, Monton Road, Eccles, nr. Manchester.)

Liquid nitrogen plant showing from right to left the regenerative H.P. drier unit, the separation unit, with dewar fitting and cold cabinets and freon compressor below.

CATALOGUES, BROCHURES & LEAFLETS
Received from Manufacturers

Polarography.—A leaflet describing the new Mervyn-WPRL polarographic electrode has been issued by Mervyn Instruments, St. John's, Woking, Surrey.

Hilger Journal.—The November 1958 issue of the Hilger Journal (Vol. V, No. 2) issued by Hilger & Watts Ltd. 98 St. Pancras Way, Camden Road, London, N.W.1, includes articles of the spectroscopic measurement of very high temperatures in Sceptre, by T. P. Hughes and R. V. Williams, and a digitized measuring machine for determining stellar declinations, by R. H. Tucker and D. S. Evans.

NEWS

General

Nuclear Power Technology

The City of Birmingham College of Technology at Gosta Green, Birmingham, 4 have issued a brochure outlining their nuclear power technology courses. The second of their College six-week full-time courses starts on April 13 and the third on November 2. In addition to these 'Harwell' and College courses, they are planning a session of one week for senior executives just after Whitsun.

These courses offer extensive experimental work in a well-equipped nuclear physics laboratory.

Micro- and Semi-Microchemical Methods

Commencing April 18, 1959, a course of 12 lectures and appropriate practical work will be held on Saturday mornings at the Norwood Technical College, London, S.E.27, from 9.15 a.m. to 12.30 p.m.

This course, which is particularly suitable for teachers, industrial and research chemists, is designed to survey the principal branches of chemistry in which small-scale methods have been successfully applied.

Lectures, illustrated by demonstrations, will deal with the following topics: Scope, aim and achievements of small-scale techniques; design and construction of simple apparatus; organic and inorganic preparations on the reduced scale; simple chemical microscopy and photomicrography; inorganic qualitative analysis; organic qualitative and quantitative analysis; physiochemical methods of analysis; chromatography; micro-techniques for the determination of molecular weight, etc.

In the main, apparatus either easily constructed or normally at hand will be used, as the course is of an essentially practical nature.

Application forms for admittance to the course may be obtained from the Secretary of the College. The London fee for the course is £1.

Manufacturers' News

African Tour

Mr. J. E. C. Bailey, C.B.E., Chairman and Managing Director of Baird and Tatlock (London) Ltd. and Hopkin and Williams Ltd. has been making a short tour of Uganda, Kenya, North Rhodesia, South Rhodesia and South Africa. He visited the companies' branches, agents and representatives in these countries to discuss general matters relating to the export of scientific equipment and chemicals.

While in North Rhodesia, Mr. Bailey visited a new branch of the companies which has recently been opened at Ndola on the Copper Belt. The opening of this new branch will facilitate the handling of the increasing volume of orders for the products of the B.T.L. Group of Companies coming from the area.

School Physics Apparatus

Charles Hearson & Company Limited announce that as from April 1, 1959, they are able to offer a wide range of school physics apparatus for experiments in mechanics, heat, light, sound, magnetism and electricity. This range of apparatus has been designed as a result of long experience and each item is of high quality and of the right type needed for school use. One of the most interesting factors concerning this apparatus is that the prices are extremely competitive throughout, while delivery can, in the majority of cases, be given from stock.

Scientific Instrument Exhibition

Evans Electroselenium Ltd. showed a full range of photo-cells and photo-electric instruments together with their galvanometers and microammeters at an exhibition of scientific instruments arranged by A. M. Lock & Co. Ltd., and held in Birmingham from March 17 to 20.

Southern Instruments form New Department

Southern Instruments announce the formation of an Analytical Instruments Department which will sell equipment designed and manufactured within the company, and also sell, and in some cases manufacture, equipment of outside design.

Further developments will follow in the polarographic field in which the company are already well known for the cathode ray polarograph, now being sold in 14 countries. Other unique analytical electronic tools will become available in the future, the first of which is the Sigrist and Weiss (Zurich) photometer, suitable for both laboratory and industrial measurement of absorption and turbidity.

Mr. W. B. Horner, formerly Sales Manager of the company, has been appointed general manager of the Analytical Department, and will be assisted by Mr. G. B. Thorpe, B.Sc., late of Plessey, on Technical Sales, and by Mr. J. Hetman, A.R.I.C. on Applications Research.

Wild-Barfield Equipment for Standard Motors Laboratory

In order that metallurgical research may be undertaken in conditions comparable with those obtaining during actual production, Wild-Barfield Electric Furnaces Ltd., of Watford, have received an order from The Standard Motor Co. Ltd., of Coventry, for a special pit type furnace for use in their laboratory. The equipment is basically a gas carburizing furnace model G.C. 1015, but is to be supplied with an atmosphere control panel that enables gas carburizing, carbonitriding or straight hardening to be carried out. There is, in addition, a hot oil quench tank operating at 140-180°C. for the purpose of reducing distortion of parts treated.

Container Charges

Since 1953 ordinary corked or capped bottles containing B.D.H. laboratory chemicals of a nominal capacity below 450 ml. have been supplied free of charge.

From February 2, this arrangement will be considerably extended, and no charge will be made for similar bottles *up to* a nominal capacity of 900 ml. or 32 fl. oz. So far as ordinary corked or capped bottles are concerned only bottles above this size will be charged and returnable in future: the rest will be regarded as being on loan and the company hope to receive them back in the normal way.

Stoppered bottles, other special bottles and all bottles containing 'AnalaR' chemicals will continue to be charged and returnable as at present.

The McArthur Microscope

Dr. John McArthur has recently announced that the manufacture and sales of his microscope are being taken over by Cooke, Troughton & Simms Ltd., York.

All enquiries should be addressed to York, and the instrument will now be known as The Cooke-McArthur microscope.

Laboratory Apparatus on Show

An exhibition of modern laboratory apparatus is to be staged by Townson & Mercer Ltd. at the Clarendon Laboratory, Oxford, during the Physical Society Conference to be held there on April 8, 9 and 10. The exhibition will be open from 10 a.m. to 5.30 p.m on the same dates.

Publications

Petroleum Testing

The 18th edition of Standard Methods for Testing Petroleum and its Products (excluding engine test methods for rating fuels) has now been published by the Institute of Petroleum at £2.

Analytical Applications of EDTA

A new publication issued by the British Drug Houses Ltd. of Poole, Dorset, by T. S. West and A. S. Sykes (4s. 6d. post free) deals with: diamino-ethane-tetra-acetic acid and its complexes; indicators for EDTA titrations; physical methods of end-point detection in EDTA titrations; the use of masking and demasking agents in EDTA titrations; determination of metals; determination of anions; determination of water hardness; the

central span for rigidity and ease of cleaning. This has meant a reduction in the weight of the set and has provided an attractive appearance. Provision is made for two lifting handles, one on each side of the unit, using the same bolt holes as for the permanent installations. The pump is driven through a Spencer Moulton 'Jubo' coupling which is adequately protected by a metal guard.

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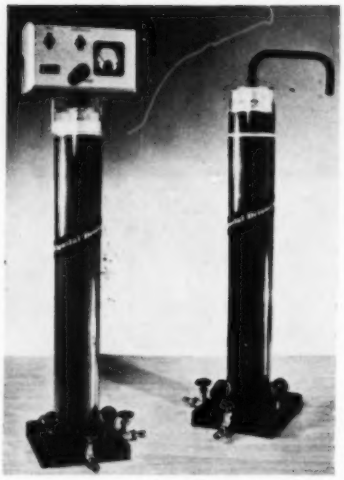

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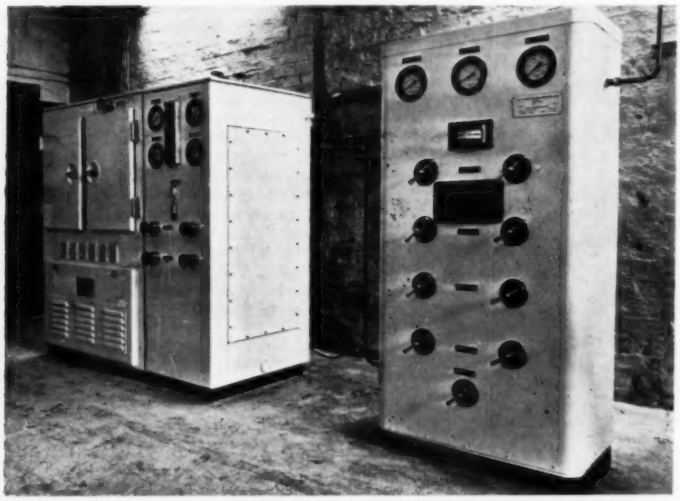
The use of regenerative driers, a caustic soda scrubber, and cross countercurrent heat exchangers, ensure long trouble-free runs. The drying and separation sections are each housed in neat, attractive, stove-enamelled cabinets. Foundations are required for the high pressure multi-stage compressor and caustic soda scrubbing tower but these units can be housed in positions remote from the other two.

The plants are fully instrumented, completely wired up electrically and only require interconnecting pipework and electricity supply cables to be installed by the user.
(Manufacturers: Refinery Equipment & Speciality Co. Ltd., Valley Works, Monton Road, Eccles, nr. Manchester.)



Liquid nitrogen plant showing from right to left the regenerative H.P. drier unit, the separation unit, with dewar fitting and cold cabinets and freon compressor below.

CATALOGUES, BROCHURES & LEAFLETS
Received from Manufacturers

Polarography.—A leaflet describing the new Mervyn-WPRL polarographic electrode has been issued by Mervyn Instruments, St. John's, Woking, Surrey.

Hilger Journal.—The November 1958 issue of the Hilger Journal (Vol. V, No. 2) issued by Hilger & Watts Ltd. 98 St. Pancras Way, Camden Road, London, N.W.1, includes articles of the spectroscopic measurement of very high temperatures in Sceptre, by T. P. Hughes and R. V. Williams, and a digitized measuring machine for determining stellar declinations, by R. H. Tucker and D. S. Evans.

NEWS

General

Nuclear Power Technology

The City of Birmingham College of Technology at Gosta Green, Birmingham, 4 have issued a brochure outlining their nuclear power technology courses. The second of their College six-week full-time courses starts on April 13 and the third on November 2. In addition to these 'Harwell' and College courses, they are planning a session of one week for senior executives just after Whitsun.

These courses offer extensive experimental work in a well-equipped nuclear physics laboratory.

Micro- and Semi-Microchemical Methods

Commencing April 18, 1959, a course of 12 lectures and appropriate practical work will be held on Saturday mornings at the Norwood Technical College, London, S.E.27, from 9.15 a.m. to 12.30 p.m.

This course, which is particularly suitable for teachers, industrial and research chemists, is designed to survey the principal branches of chemistry in which small-scale methods have been successfully applied.

Lectures, illustrated by demonstrations, will deal with the following topics: Scope, aim and achievements of small-scale techniques; design and construction of simple apparatus; organic and inorganic preparations on the reduced scale; simple chemical microscopy and photomicrography; inorganic qualitative analysis; organic qualitative and quantitative analysis; physiochemical methods of analysis; chromatography; micro-techniques for the determination of molecular weight, etc.

In the main, apparatus either easily constructed or normally at hand will be used, as the course is of an essentially practical nature.

Application forms for admittance to the course may be obtained from the Secretary of the College. The London fee for the course is £1.

Manufacturers' News

African Tour

Mr. J. E. C. Bailey, C.B.E., Chairman and Managing Director of Baird and Tatlock (London) Ltd. and Hopkin and Williams Ltd. has been making a short tour of Uganda, Kenya, North Rhodesia, South Rhodesia and South Africa. He visited the companies' branches, agents and representatives in these countries to discuss general matters relating to the export of scientific equipment and chemicals.

While in North Rhodesia, Mr. Bailey visited a new branch of the companies which has recently been opened at Ndola on the Copper Belt. The opening of this new branch will facilitate the handling of the increasing volume of orders for the products of the B.T.L. Group of Companies coming from the area.

School Physics Apparatus

Charles Hearson & Company Limited announce that as from April 1, 1959, they are able to offer a wide range of school physics apparatus for experiments in mechanics, heat, light, sound, magnetism and electricity. This range of apparatus has been designed as a result of long experience and each item is of high quality and of the right type needed for school use. One of the most interesting factors concerning this apparatus is that the prices are extremely competitive throughout, while delivery can, in the majority of cases, be given from stock.

Scientific Instrument Exhibition

Evans Electroselenium Ltd. showed a full range of photo-cells and photo-electric instruments together with their galvanometers and microammeters at an exhibition of scientific instruments arranged by A. M. Lock & Co. Ltd., and held in Birmingham from March 17 to 20.

Southern Instruments form New Department

Southern Instruments announce the formation of an Analytical Instruments Department which will sell equipment designed and manufactured within the company, and also sell, and in some cases manufacture, equipment of outside design.

Further developments will follow in the polarographic field in which the company are already well known for the cathode ray polarograph, now being sold in 14 countries. Other unique analytical electronic tools will become available in the future, the first of which is the Sigrist and Weiss (Zurich) photometer, suitable for both laboratory and industrial measurement of absorption and turbidity.

Mr. W. B. Horner, formerly Sales Manager of the company, has been appointed general manager of the Analytical Department, and will be assisted by Mr. G. B. Thorpe, B.Sc., late of Plessey, on Technical Sales, and by Mr. J. Hetman, A.R.I.C. on Applications Research.

Wild-Barfield Equipment for Standard Motors Laboratory

In order that metallurgical research may be undertaken in conditions comparable with those obtaining during actual production, Wild-Barfield Electric Furnaces Ltd., of Watford, have received an order from The Standard Motor Co. Ltd., of Coventry, for a special pit type furnace for use in their laboratory. The equipment is basically a gas carburizing furnace model G.C. 1015, but is to be supplied with an atmosphere control panel that enables gas carburizing, carbonitriding or straight hardening to be carried out. There is, in addition, a hot oil quench tank operating at 140-180°C. for the purpose of reducing distortion of parts treated.

Container Charges

Since 1953 ordinary corked or capped bottles containing B.D.H. laboratory chemicals of a nominal capacity below 450 ml. have been supplied free of charge.

From February 2, this arrangement will be considerably extended, and no charge will be made for similar bottles *up to* a nominal capacity of 900 ml. or 32 fl. oz. So far as ordinary corked or capped bottles are concerned only bottles above this size will be charged and returnable in future: the rest will be regarded as being on loan and the company hope to receive them back in the normal way.

Stoppered bottles, other special bottles and all bottles containing 'AnalaR' chemicals will continue to be charged and returnable as at present.

The McArthur Microscope

Dr. John McArthur has recently announced that the manufacture and sales of his microscope are being taken over by Cooke, Troughton & Simms Ltd., York.

All enquiries should be addressed to York, and the instrument will now be known as The Cooke-McArthur microscope.

Laboratory Apparatus on Show

An exhibition of modern laboratory apparatus is to be staged by Townson & Mercer Ltd. at the Clarendon Laboratory, Oxford, during the Physical Society Conference to be held there on April 8, 9 and 10. The exhibition will be open from 10 a.m. to 5.30 p.m on the same dates.

Publications

Petroleum Testing

The 18th edition of Standard Methods for Testing Petroleum and its Products (excluding engine test methods for rating fuels) has now been published by the Institute of Petroleum at £2.

Analytical Applications of EDTA

A new publication issued by the British Drug Houses Ltd. of Poole, Dorset, by T. S. West and A. S. Sykes (4s. 6d. post free) deals with: diamino-ethane-tetra-acetic acid and its complexes; indicators for EDTA titrations; physical methods of end-point detection in EDTA titrations; the use of masking and demasking agents in EDTA titrations; determination of metals; determination of anions; determination of water hardness; the

use of EDTA in the analysis of technical materials; EDTA as a masking agent; and analytical applications of other 'complexones'.

Also incorporated in the publication is a comprehensive section of 468 references.

Scientific and Technical Conferences

List No. 24 Forthcoming International Scientific and Technical Conferences, published by the Department of Scientific and Industrial Research, amends and amplifies the information contained in List No. 23 which is superseded. The List covers all scientific and technical conferences of an international character, held in the United Kingdom, or elsewhere, of interest to British Government Departments, British Government-supported research laboratories and other scientific organizations.

Plastics in the Tropics

No. 10 in the series Reports on Plastics in the Tropics has now been published for the Ministry of Supply by H.M.S.O. (price 6s.) and deals with synthetic resin bonded laminated sheet.

Sixteen synthetic resin bonded laminated sheet materials were exposed for two years at three humid sites at Port Harcourt and a dry site at Kano, Nigeria. Specimens exposed to sun and rain suffered loss of surface gloss, weathering of the surface and discoloration. Brass inserts showed corrosion which did not affect any of the plastics. None of the specimens showed any sign of warping and delamination was confined to one grade of impregnated compressed wood. Termite attack was confined to one material, a phenol formaldehyde resin laminate with paper base, which was buried at Kano. The majority of the specimens increased in weight at the humid sites and decreased at the dry site. One material showed an increase in cross breaking strength. There was a wide scatter in the dimensional changes. Two materials showed a reduction in modulus of elasticity in tension. Insulation resistance decreased at all sites. Power factor deteriorated at the humid sites and an initial improvement noticed at the dry site was not maintained.

D.S.I.R. Grants

Under its second Five-Year Plan, the Department of Scientific and Industrial Research proposes to make a substantial increase in the number of its Postgraduate Studentships and Fellowships in science and technology. There are now nearly 1,900 postgraduate students supported by D.S.I.R. and this number is expected to rise to about 3,800 by 1963-64 in which year expenditure on this scheme, at current rates, is likely to exceed £1,500,000.

In addition, the amount of money available under the D.S.I.R. scheme of Grants for Special Researches to assist research projects in science and technology at universities and colleges is expected to increase between three and four fold, rising to about £1,750,000 for 1963-64. (This provision will include funds for the promotion of research in the human sciences in relation to industrial needs.)

Full details of the regulations governing these grants are contained in the 1959 edition of 'Notes on D.S.I.R. Grants for Graduate Students and Research Workers', published for D.S.I.R. by H.M.S.O., price 1s. 9d.

L.L.U. Translations Bulletin

The Department of Scientific and Industrial Research's Lending Library Unit is introducing a new monthly publication under the title 'The L.L.U. Translations Bulletin'. It aims to provide British scientists and engineers, who are anxious to have details of current U.S.S.R. research, with up-to-date information on the availability of Russian translations. (Published for D.S.I.R. by H.M.S.O., price 4s. Annual Subscription £2. 13s.)

The Bulletin contains lists of books, journals and other scientific papers which are now available or which are being translated and will become available in the near future. One section deals with cover-to-cover translations—a scheme for providing a complete Russian technical journal in the English language—and another gives details of the work being carried out by the National Science Foundation in the United States, with whom the L.L.U. collaborates in this translation scheme. Many translations from America are held in London on microfilm and photo-copies may be borrowed.

The Bulletin also contains articles on new scientific developments in Russia. These can be followed up in detail with the aid of L.L.U.'s comprehensive collection of Russian scientific literature.

It is contemplated that in the future the Bulletin will cover other language translations.

MEETINGS FOR THE MONTH

Mid-April to Mid-May

We give below a selection of meetings of interest to laboratory workers. Details are as full as possible at the time of going to press, but readers requiring further information or confirmation of arrangements should contact the organizers.

April 9

The Society for Analytical Chemistry (Midlands Section). At The University, Birmingham, 3. 6.30 p.m. 'Analytical Chemistry in Glass Manufacture', by J. Davies.

April 10

The Society of Instrument Technology (Cheltenham Section). At the Rotunda, Cheltenham. 7.30 p.m. Annual General Meeting followed by 'Automation Behind the Iron Curtain'.

The Society of Instrument Technology (Midland Section). At Regent House, St. Phillips Place, Colmore Row, Birmingham 3. 7 p.m. Annual General Meeting and Film Show.

April 11

The Society for Analytical Chemistry (North of England Section). At City Laboratories, Mount Pleasant, Liverpool. 2.15 p.m. 'The Training of Analytical Chemists', by G. F. Longman.

April 15

The Society of Instrument Technology (Newcastle Section). At King's College, Stephenson Buildings, Newcastle-upon-Tyne. 7 p.m. 'Radiation Pyrometers', by R. Barber.

April 16

The Society of Instrument Technology (East Midland Section). At College of Further Education, Greenclose Lane, Loughborough. 6.30 p.m. Annual General Meeting followed by an address by the President.

April 24

The Royal Institute of Chemistry (London Section). At Leatherhead, Canteen of the British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey. 6.0 p.m. 'Some Recent Results Obtained by the Method of Flash Photolysis', by Prof. R. G. W. Norrish.

April 28

The Society for Analytical Chemistry (Physical Methods Group). At Chemistry Department, Brunel College of Technology, Acton, London, W.3. 6.30 p.m. Demonstration of Laboratory-made Equipment.

April 29

The Society of Instrument Technology (Chester Section). In the lecture theatre of the Grosvenor Museum, Grosvenor Street, Chester. 7 p.m. Annual General Meeting and Film Show.

May 6

The Society of Instrument Technology (London). Manson House, Portland Place, W.1. 5.30 p.m. Annual General Meeting, followed by the Presidential Address.

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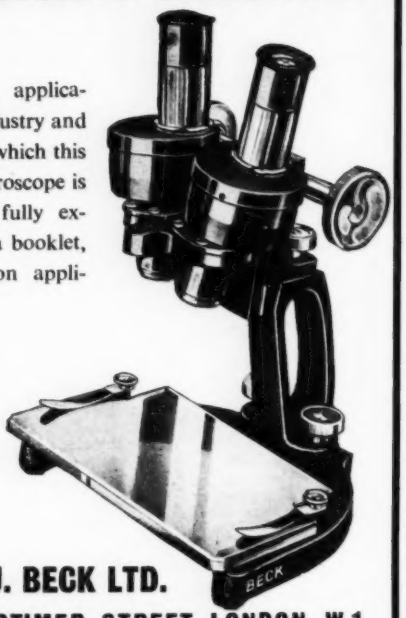

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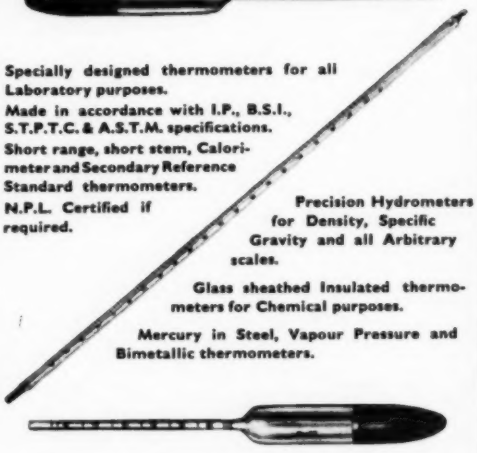

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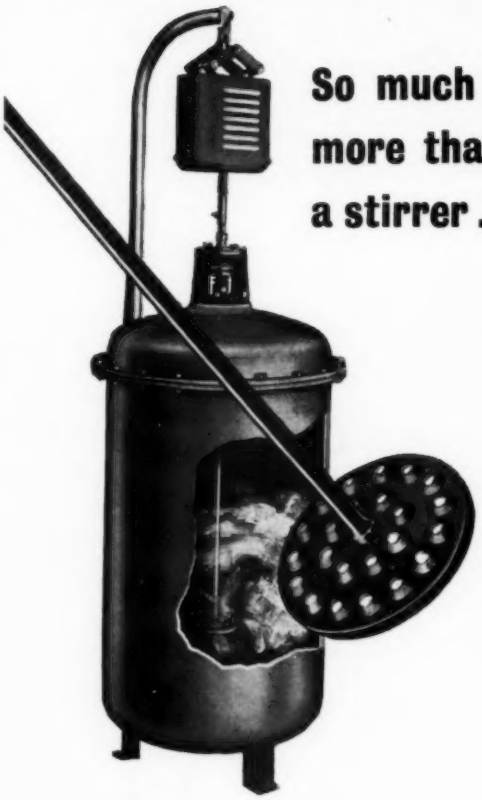

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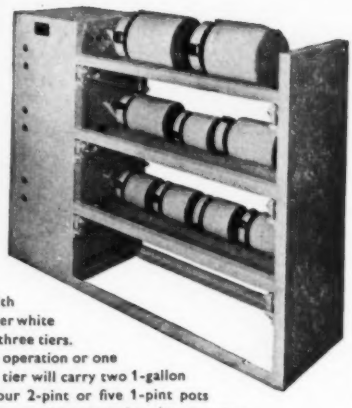

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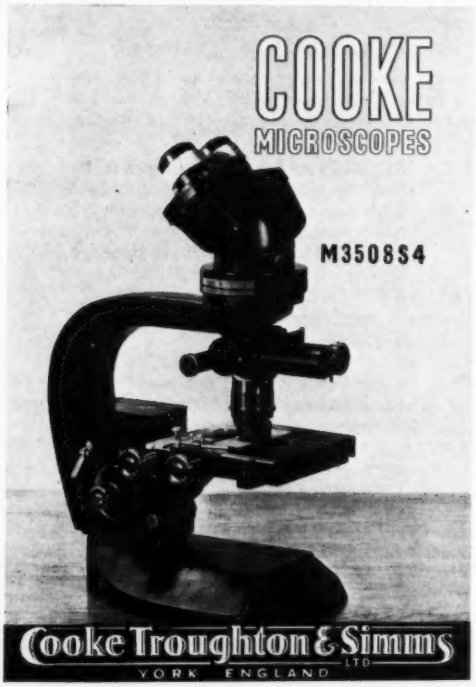

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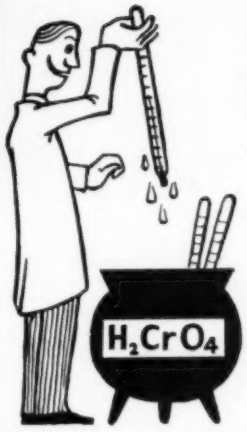

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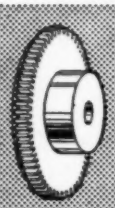

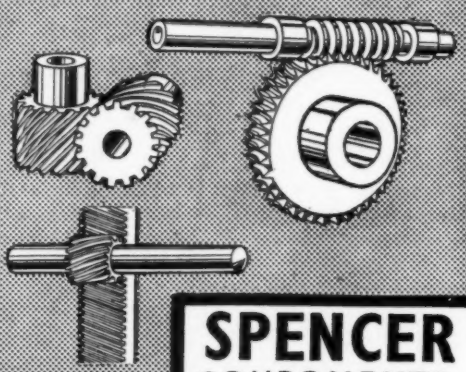

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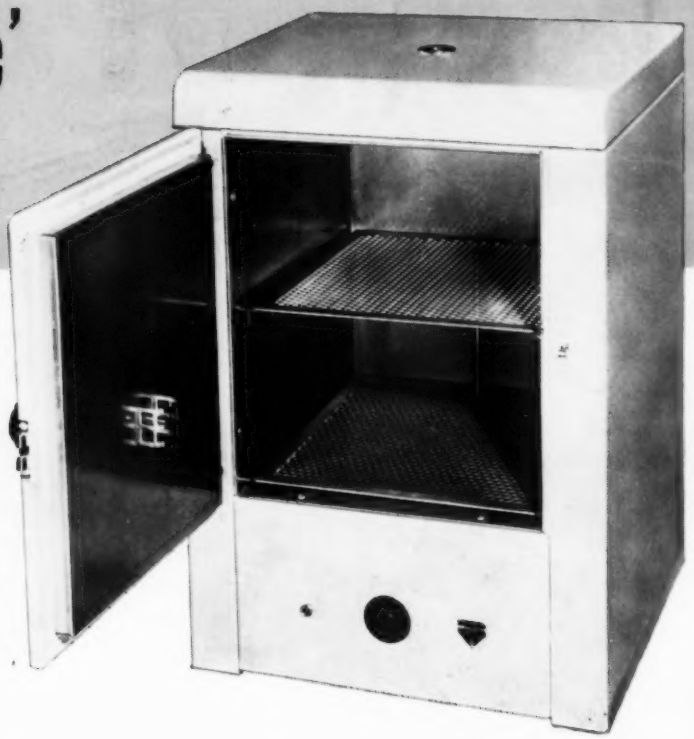

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